ERICSSON Review

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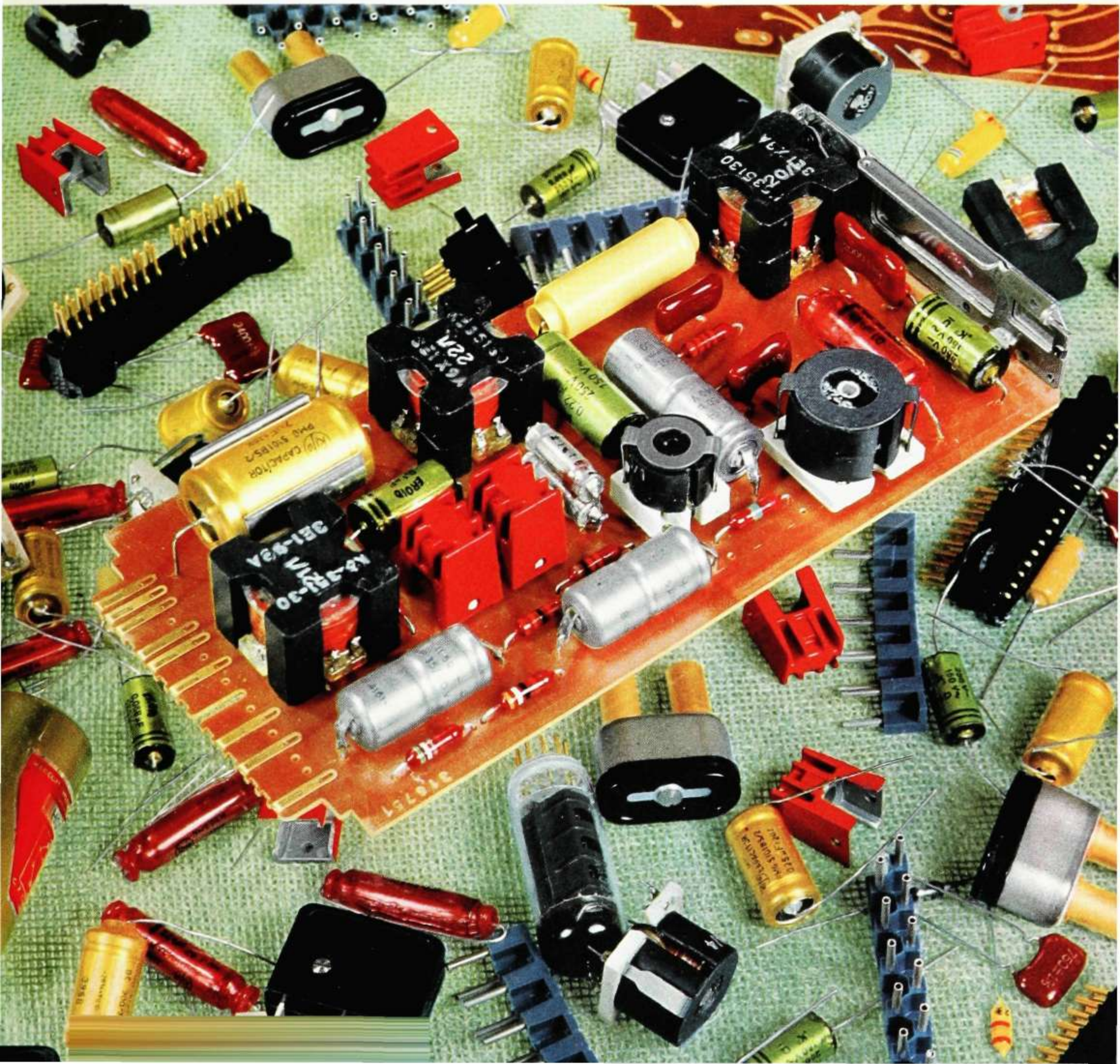
1961



ERICSSON REVIEW

Vol. XXXVIII 1961

RESPONSIBLE PUBLISHER: HUGO LINDBERG

EDITOR: SIGVARD EKLUND, DHS

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On cover: Channel amplifier and some of the components in L M Ericsson's new transistorized carrier frequency systems.

A New Method of Construction for Transmission Equipment

III. Electrical Components

P O HARRIS & N HELLKVIST, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

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This article describes a selection of the most important electrical components used in L M Ericsson's new method of transmission equipment construction. Some of these components have been developed and are manufactured by L M Ericsson, others have been developed within the group but are manufactured by outside firms, while a third class, perhaps with a small turnover but nevertheless needing special equipment, is both designed and manufactured by outside firms. The construction of the components and their most important characteristics are described, especially those which have been a deciding factor in the choice of component type.

General

Since World War II, rapid development has taken place in the component field. Electrical components used earlier in important electrical equipment often had to be drawn from the entertainment industry, where requirements for reliability and high performance usually took second place to ease of manufacture or low cost. As military and industrial electronics have increased in volume and importance, component manufacturers have come to appreciate the requirements of these fields and have also started producing high-grade components. This has eased the situation for manufacturers of transmission equipment who formerly often were compelled to try to produce high-quality components in relatively small batches, resulting in high manufacturing costs.

But component development has not only been affected by the demand for reliability. Many new materials and methods have led to a reduction in component size concurrently with the improvement in performance. For carrier technique the most important advances have been the introduction of ferrite materials and semiconductors. These allow reduced equipment dimensions, improved performance and lower costs of operation and maintenance.

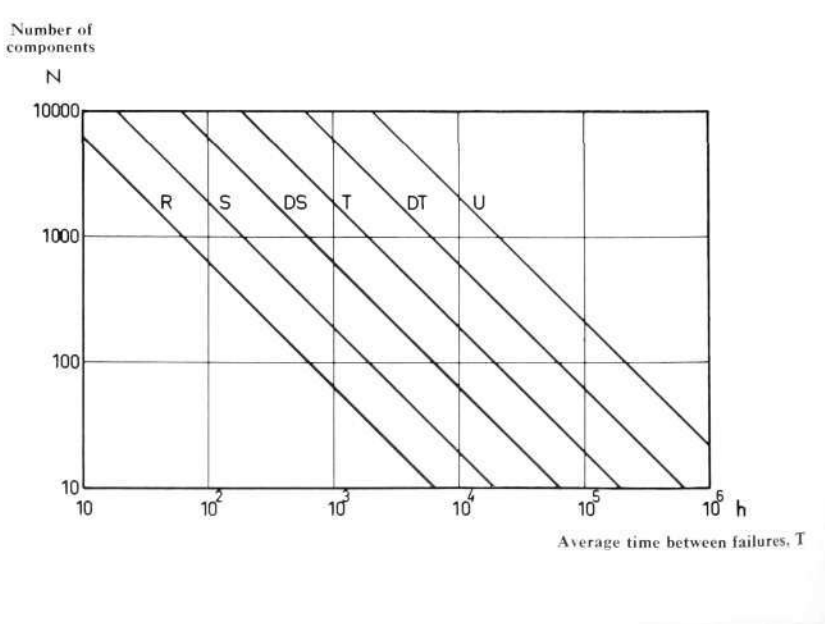


Fig. 1 X 8250

Average time between failures in an equipment as a function of its number of components and their grades of reliability

Reliability grade R — 1.5 % per 1 000 hours
S — 0.5 % per 1 000 hours
DS — 0.15 % per 1 000 hours
T — 0.05 % per 1 000 hours
DT — 0.015 % per 1 000 hours
U — 0.005 % per 1 000 hours

Among other fields which have undergone a rapid development is that of capacitors, where new plastic materials permit smaller size and where vapour deposition of metal in vacuum has revolutionized manufacturing processes. This has resulted in capacitors with new and more desirable characteristics.

The equipment used in transmission technique is as a rule very complex and contains a great many parts, some of mechanical and some of electrical character. The mechanical items have already been dealt with in an earlier article, but some of them (contacts) have also a very important electrical function, so they will also be discussed here. In a single connexion many thousands of components with electrical functions may be involved, and it is important that they all work properly, since failure in a single one can result in a faulty connexion. Fig. 1 shows the relationship between equipment complexity and the average time between failures for various values of component reliability. The reliability is usually expressed as the percentage failing in unit time, normally percentage per 1 000 hours. It can be seen from the diagram that the average time between failures falls rapidly as the number of components in an item of equipment rises, for a given component reliability.

Transistors

When the transistor was born 12 years ago, it was asserted that a component with very good efficiency and very long life had appeared – it was even said that its life ought to be unlimited. Comparisons were made with the electron tube, whose cathode wears out during use, and it was supposed that since no material is used up in the transistor, its properties ought to remain unchanged with time. But it soon transpired that the idea of unlimited life was not fulfilled

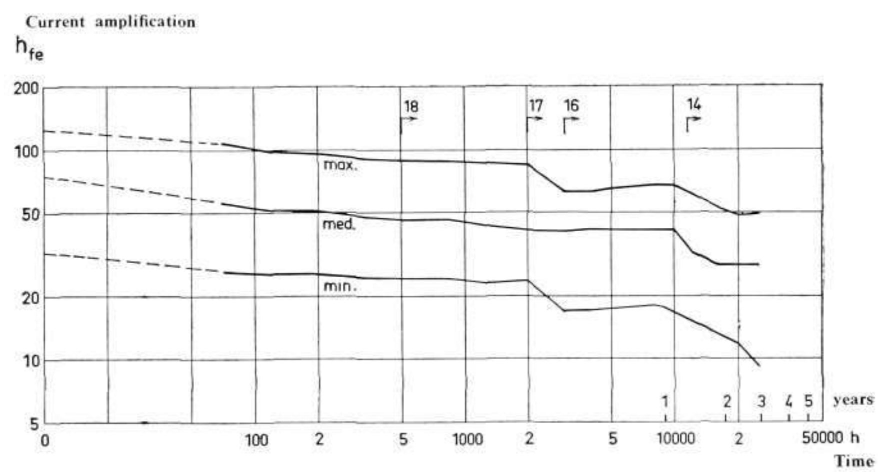


Fig. 2 X 8260

Variation of current amplification with time for 20 ordinary transistors with 30 mW dissipation at room temperature

The figures above the curves give the number of transistors left after elimination of catastrophic failures.

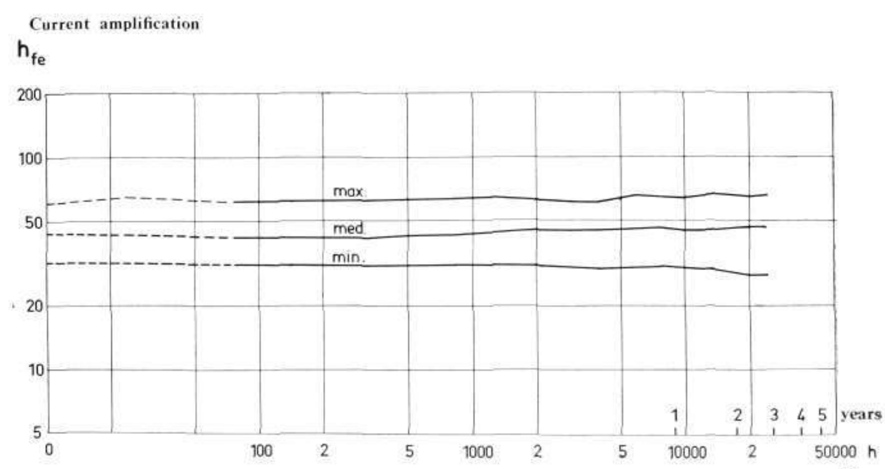


Fig. 3 X 8252

Variation of current amplification with time for 20 high-quality transistors with 150 mW dissipation at room temperature

in practice: a number of secondary phenomena interfered with operation. Manufacture turned out to be a very delicate job needing great care and cleanliness. The transistor element was found to be affected by gases, especially water vapour, so that hermetic sealing was necessary. Today's transistors differ considerably from those first produced, not only in that the original type (the point contact transistor) have been abandoned in favour of later forms (the junction transistors), but also due to experience gained in how the various parts and finished units should be treated in order to get good results.

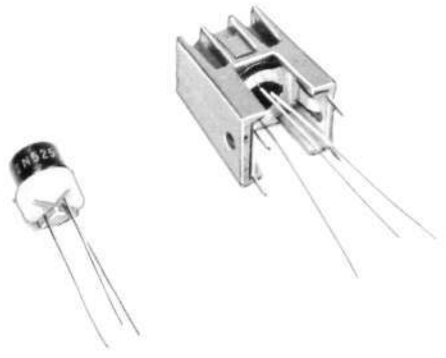


Fig. 4 X 2561

Transistors mounted on lead spacer (left) and on heat sink (right)

Transistors have from the start been used in equipment where their small volume and lower power consumption have been important, e.g. in portable receivers, hearing aids etc. In such relatively simple equipment defects in quality are less noticeable. Ordinary transistors have a failure rate of the order of 1 to 10 % per 1 000 hours; these failures comprise both catastrophic faults (short-circuits between transistor electrodes, open-circuits inside the envelope etc.) and also severe deterioration of characteristics (increase in leakage current, changes in current amplification etc). Fig. 2 shows the results of laboratory investigations of such types of transistors. A batch of 20 transistors was operated with 30 mW dissipation at room temperature. Various characteristic data were measured at intervals: the diagram shows the median, maximum and minimum values of current amplification as a function of time. It can be seen that the changes were very large and several catastrophic failures accurred.

Transistors for use in transmission equipment must have considerably higher reliability. Fig. 3 shows the result of an aging test on 20 good-quality transistors with 150 mW collector dissipation at room temperature. It will be seen that changes are quite insignificant and no catastrophic failures occurred. The same type of curve was also obtained for other types of life test, e.g. shelf life at high temperatures, + 100° C.

Various tests on transistors of more or less high quality have shown that the stresses on transistors, and hence the fault rate, increase with the temperature of the semiconductor element. It is therefore important to keep the temperature as low as possible, and fig. 4 shows a transistor used mainly in transmission equipment and provided with a simple plastic lead spacer, and the same transistor provided with a heat sink. Such a heat sink lowers the excess temperature due to power dissipation in the transistor by 40 %, and is used as soon as the collector dissipation exceeds some tens of milliwatts.

Diodes

Modulator Diodes

A component of basic importance for transmission technique is the modulator diode, used in the ring modulator for frequency translation of channels or groups of channels. Before the advent of monocrystalline diodes, electron tube diodes or copper oxide rectifiers were used: neither of these types was precisely ideal because of their large changes in forward resistance with age. Nowadays germanium diodes are used and offer significant advantages. In L M Ericsson's new method of construction they are mounted in sets of 4 as sub-assemblies, as shown in fig. 5.

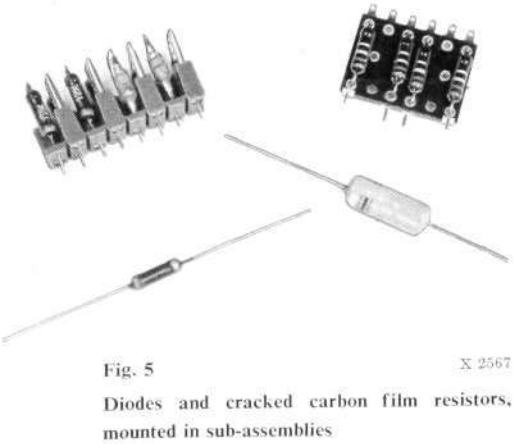


Fig. 5 X 2567

Diodes and cracked carbon film resistors, mounted in sub-assemblies

Unmounted resistors in the foreground

If the four diodes in a ring modulator exhibit inequality of forward resistance, a direct carrier leak through the modulator occurs. Careful sorting of the diodes is necessary for all four forward characteristics to match. But even when a matched set of diodes has been selected, it is essential that the stability of their forward resistances be such that they stay well balanced in spite of aging. To investigate stability, the forward resistances of pairs of diodes were compared in a bridge circuit and the unbalance voltage measured

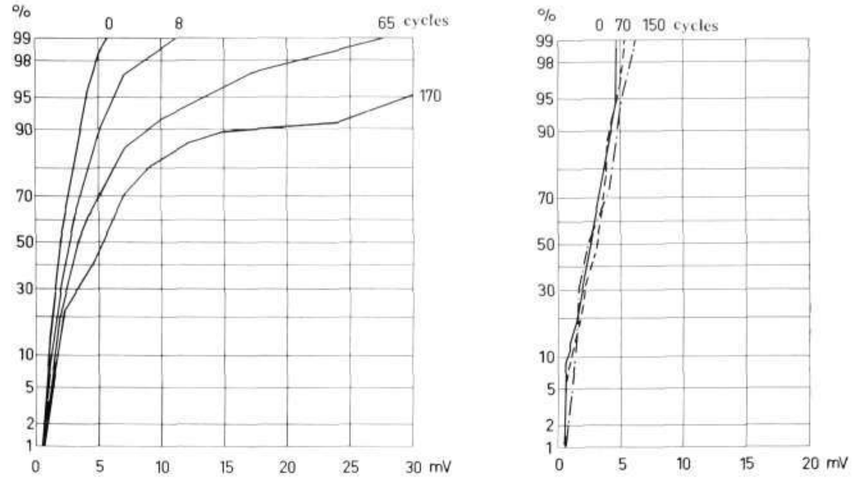


Fig. 6 X 2546 X 2547

Distribution curve of unbalance voltage, when forward resistances of a pair of diodes are compared in a bridge, as a function of aging by temperature cycling between + 70° C and — 20° C

a) for an ordinary entertainment type
b) for special diodes for transmission service

for a given applied voltage. Fig. 6 shows how this unbalance voltage varies with time during temperature cycles of from + 70° C to − 20° C, for an ordinary type of diode for entertainment applications and for a special type of diode developed for transmission purposes respectively. It can be seen that the unbalance voltage increases rapidly for the entertainment type, whereas for the special type the changes are so small as to lie within the limits of measurement accuracy, due to the differences of temperature between successive measurements.

Rectifier Diodes

For power rectifiers the silicon diode has nowadays replaced the rectifier tube and the selenium rectifier. Fig. 7 shows, above, three different sizes of silicon rectifier for 0.75 A, 3 A and 10 A rectified d.c. respectively. Some of the advantages of silicon diodes are low forward voltage drop, high permissible reverse voltage, and small dimensions. This means high efficiency and low power dissipation in the rectifier units, while at the same time transformer construction is simplified since voltage tappings, required with selenium rectifiers to compensate for aging, are no longer needed.

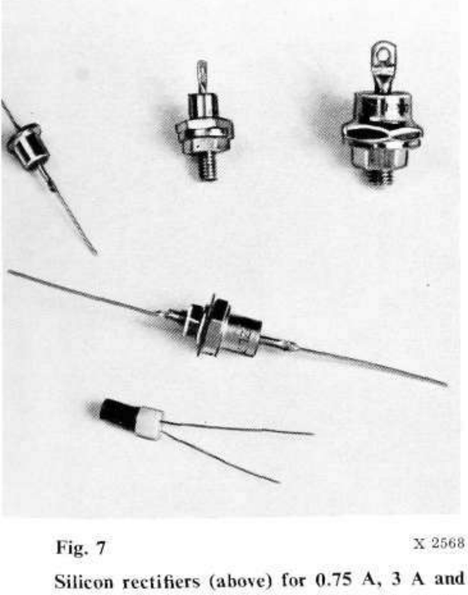


Fig. 7 X 2568

Silicon rectifiers (above) for 0.75 A, 3 A and 10 A rectified d.c., Zener diode for 1.25 W dissipation, and (below) for 250 mW dissipation

Zener Diodes

The Zener diode is a semiconductor component whose properties allow many applications: it makes use of a constant reverse breakdown voltage for voltage stabilizing. Two Zener diodes are shown in fig. 7, below, one for 250 mW dissipation and the other for 1.25 W. The permissible dissipation of the latter can be increased by the use of a heat sink up to some 5 W. Various Zener voltages in the range 5 to 100 V can be obtained by doping the silicon crystal with suitable amounts of impurity, and Zener diodes can therefore be used either for voltage stabilizing or for protection against overvoltages in sensitive equipment.

Resistors

Transistorizing of transmission equipment has meant a great decrease in the need of resistors with high values of resistance and for higher dissipation. More than 95 % of all resistors dissipate less than 0.25 W, and therefore only two types of cracked carbon resistors have been standardized–see fig. 5. The smaller type is rated by the manufacturer at a nominal $^1/_3$ W and the larger

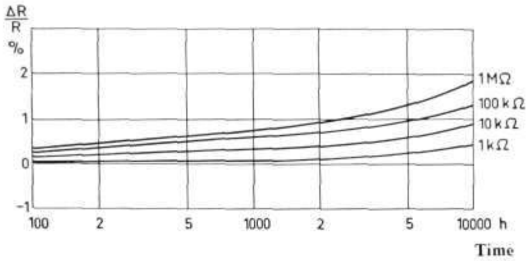


Fig. 8 X 2548

Change in resistance of cracked carbon film resistors during damp heat test: + 40° C, 90—95 % RH, with a small d.c. voltage across the resistors (negligible heat developed)

at 2 W. To increase reliability, the maximum dissipation permitted in our equipment is 0.25 W and 1 W respectively. The resistors are either mounted directly on the printed wiring card or in sub-assemblies, as seen in fig. 5.

Only tolerances of ± 2 and ± 5 % are permitted, thus keeping down the profusion of resistor values needing to be kept in stock. This also means of course that larger batches of resistors of the same value are produced, resulting in better quality. Naturally the demands on stability and reliability are equally exacting. Fig. 8 shows change in resistance as a function of time for cracked carbon resistors during a damp heat test at + 40° C with a relative humidity of 90–95 %. It can be seen that the stability is very good: resistance changes are less than 2 % for resistors up to 1 megohm during up to one year's testing. Such a severe strain never occurs in actual operation. The higher values of resistance naturally exhibit greater changes than the lower, since the carbon layer is thinner. During the test a small d.c. voltage is applied across the resistor, since it has been found that under humid conditions this can give rise to electrolytic corrosion in resistors from many manufacturers. This voltage is so low, however, that heating of the resistor is negligible.

Magnetic Components

Amongst the components used in transmission equipment, those whose earlier design was least suited to printed wiring were magnetic components, i.e. inductors and transformers: it has therefore been necessary to redesign them completely. At the same time better performance and smaller dimensions were sought. By a happy coincidence the development of ferrite materials now permits the realization of more complex core shapes having better characteristics without any undue increase in cost–in fact in some cases costs are actually decreased due to the elimination of the expensive process of interleaving cores of thin laminations.

Besides the new ferrites, other advances in materials have been exploited, for instance thermo-setting resins for uniting component parts, and plastic or ceramic materials for coil bobbins and holders. In this connexion moisture protection and corrosion questions have been carefully studied: to achieve good resistance to moisture and corrosion all inductors and transformers are vacuum-impregnated with suitable wax. It is also an advantage that ferrite

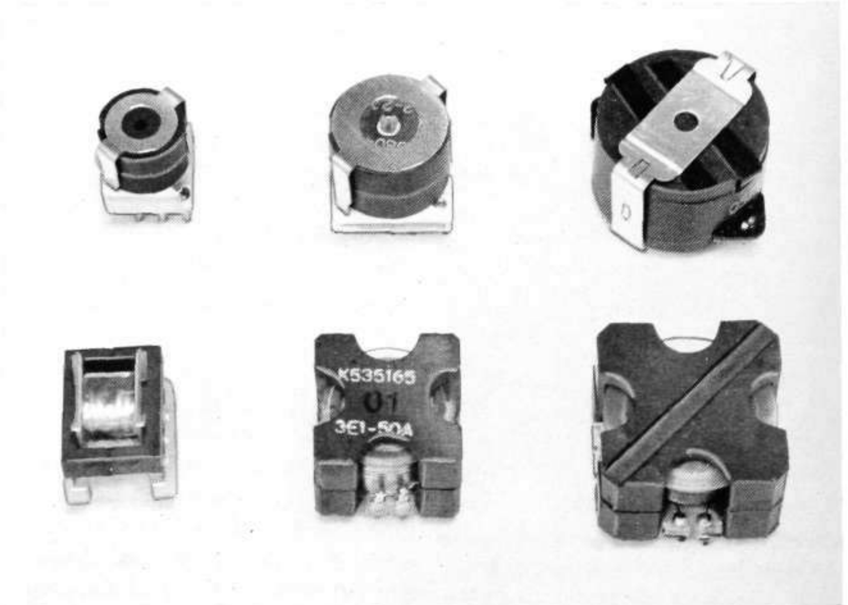


Fig. 9 X 8259

Above: Ferrite-cored adjustable inductors for printed wiring:

l. to r. REG 112, REG 111, REG 101

Below: Ferrite-cored transformer for printed wiring:

l. to r. REG 203, REG 301, REG 302

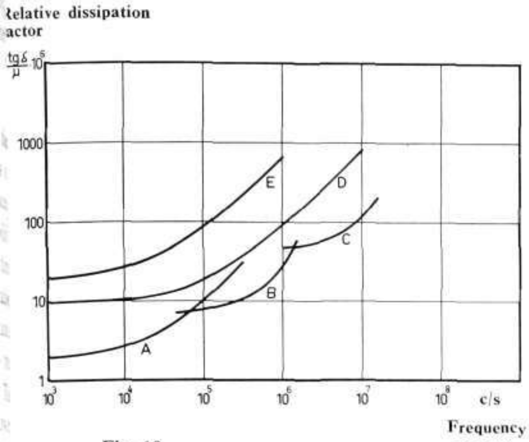


Fig. 10

Relative dissipation factor as a function of frequency for:

A MnZn-type ferrite with $\mu = 1\,200$
B MnZn-type ferrite with $\mu = 600$
C NiZn-type ferrite with $\mu = 100$
D Carbonyl iron dust with $\mu = 15$
E Carbonyl iron dust with $\mu = 60$

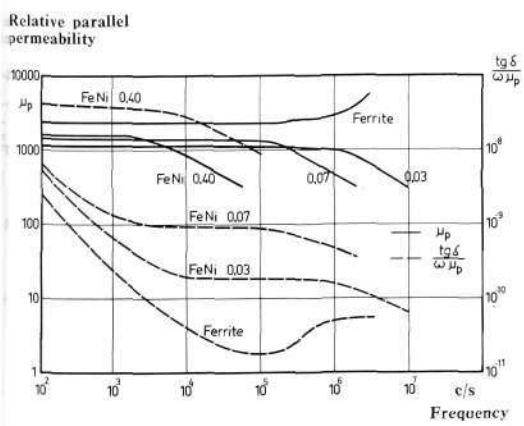


Fig. 11

Relative parallel permeability μ_p and dissipation function (tan δ) $\omega\mu_p$ as a function of frequency, for nickel-iron laminations of different thicknesses and for MnZn-ferrite with $\mu = 2000$

materials are inherently inert to moisture and resistant to corrosion, in contrast to the carbonyl iron cores used earlier.

The forms chosen for the magnetic components which make them suitable for printed wiring cards can be seen in fig. 9. One naturally wants to utilize a given space as effectively as possible, while at the same time allowing for connexion of leads to the soldering tags in the most rational way, and providing a simple fixing to the wiring card. When almost entirely closed ferrite pot cores are used, an inductor has to have a separate holder with soldering tags fixed on its under side. For transformers, (fig. 9, below) where the bobbin is only partially enclosed by the core, it has been possible to fix solder tags directly into the bobbin. This also leads to simplified production, since the winding leads can be connected directly to the tags at the winding stage.

The smaller components are fixed to the wiring card by their soldering tags only: the heavier components are additionally secured by a fixing bracket. Results of mechanical tests show that this ensures the equipment being safe against all the shocks and vibrational strains of transport, loading and unloading, etc.

Core Material

One of the principal limitations on performance of earlier magnetic components was eddy current losses in the core material. Various means of reducing these have been tried–for inductors by the use of finely divided iron dust, held together by a binding agent, and for transformers by the use of thin insulated tape or laminations. This limitation due to eddy current losses is normally absent for ferrites due to their high resistivity. The losses which instead are significant are frequency-dependent residual losses; it is the sum of these plus the copper losses which determine the performance (Q-factor) achievable with the magnetic components.

Fig. 10 shows a comparison between the relative dissipation factors (tan δ)/μ for three typical ferrite materials and two very common grades of carbonyl iron dust. The quantity (tan δ)/μ is characteristic for the losses of the material and is independent of the air gap and material permeability. An inductor with a given magnetic circuit–a particular air gap and thus a defined value of effective permeability μ_{eff}–has core losses for different core materials which are directly proportional to (tan δ)/μ. It will be seen from the curves that within the entire frequency range 1 kc/s to 10 Mc/s, inductors can be made with ferrite cores having lower core losses than with the carbonyl iron dust cores previously used.

Besides the lower dissipation factor due to after-effect and eddy current losses, ferrites have also lower hysteresis losses and lower harmonic distortion than carbonyl iron, which is of great importance in certain applications.

To assess the effect on the losses in a transformer of the magnetic material of its core, it is convenient to consider the equivalent circuit of the core as a parallel combination of an inductance and a dissipation resistance shunted across the transformer load. Fig. 11 shows the corresponding parallel permeability μ_p as a function of frequency for nickel iron laminations of thickness 0.40, 0.07 and 0.03 mm (16, 2.8 and 1.2 mils), and for a typical transformer ferrite. The dashed lines on the same diagram show the dissipation function (tan δ)/$\omega\mu_p$. For a given type of transformer with a given number of turns, the loss due to magnetic dissipation is proportional to this function. It can be seen that the loss is appreciably lower with the ferrite core. The latter also

gives considerably smaller variations in loss over the frequency band 0.1 to 1 Mc/s than, say, the 0.07 mm nickel iron laminations, and is, moreover, economically preferable. Because of the high cost of handling and interleaving thin stampings, 0.03 mm nickel iron was only used in the form of reeled tape cores.

Inductors

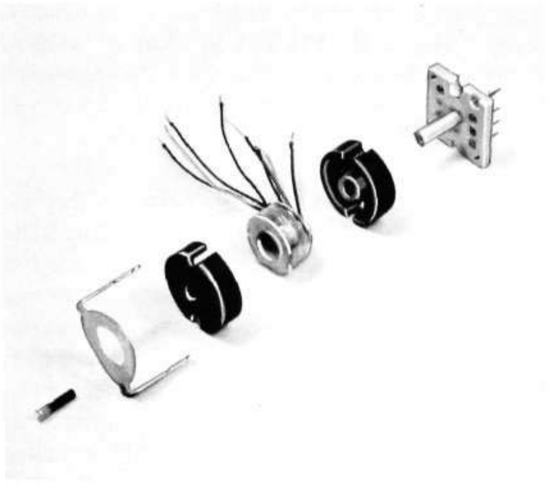
The high permeability and good magnetic properties of ferrites have made it possible to produce inductors with considerably reduced dimensions compared with their electrical equivalents using carbonyl iron dust. Fig. 12 makes this clear: three new inductor types are shown for comparison with three older types with respectively corresponding performance. The reduced size and changed design of the inductors has led to simplification of the actual winding process and to a reduction in the amount of copper used by over 80 %.

For inductors it is seldom possible to exploit the high permeability of ferrites, because an air-gap must be included (usually placed in the centre of the core): this air-gap results in a reduction not only in the effective permeability but also in undesirable features such as instability, dissipation and temperature dependence. A further advantage of the air-gap is that a small movable piece of ferrite can be inserted there for trimming. This gives a convenient way of taking up the manufacturing tolerances, both of inductors and also of associated capacitors, by adjustment of tuned circuits to the desired resonant frequency. Earlier designs used adjustment of the number of turns during manufacture to obtain the desired inductance, and adjustment of the resonant frequency had to be made either by variable trimmer capacitors or by connecting up separate adjusting capacitors. Using a trimmer core, an inductance variation of some 10 % can be obtained without significantly altering the stability or Q of the inductor, and adjustment sensitivity is better than 0.01 %. Another possibility of adjustment of inductance during manufacture is by altering the air-gaps by grinding the core, and since this involves no change in the winding, it provides a convenient and rational method for coarse adjustment.

Using a trimmer core must not, of course, be allowed to make stability or dependence on temperature worse. The trimmer mechanism must therefore be firmly fixed and constructed so that no movement can occur due to vibration

Fig. 12 X 8255

Inductors with ferrite cores for printed wiring and earlier types with equivalent performance using toroidal carbonyl iron dust cores



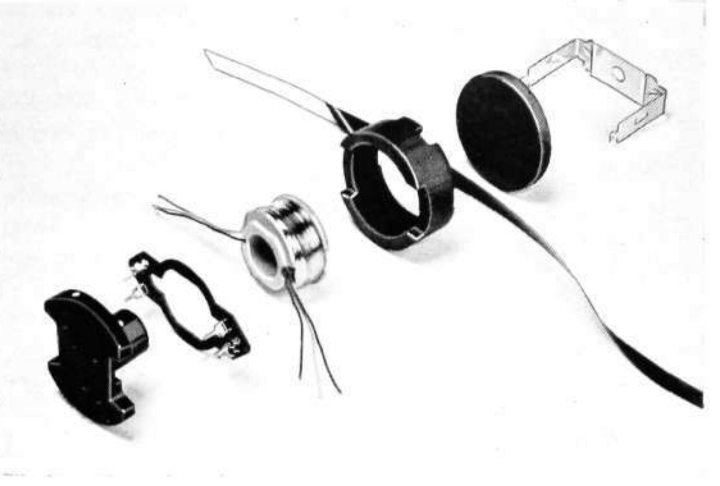


Fig. 13 X 8256 X 8257

Exploded view of ferrite inductors: lef', smaller type REG 111; right, larger type REG 101

or shock, or due to changes in temperature or humidity. Fig. 13 shows exploded views of two types of inductor to show the assembly of the various parts.

In the smaller inductors, the holder serves as support for the trimmer core, which has a plastic screw thread. A special fixture (Swedish patent No. 172 073) takes up play and makes the trimmer screw insusceptible to vibration, yielding a trimming arrangement producing practically no degradation of the inductor stability. Fig. 14 shows the change of inductance with time, with a daily temperature cycle between $+ 55^\circ$ C and $- 20^\circ$ C, for inductors with and without a trimmer core. It will be seen that the changes are very small and the differences between the inductors with and without a trimmer are practically negligible.

For larger inductors trimming is done by a plastic tape carrying a layer of ferrite of gradually decreasing thickness. This tape is drawn through the airgap till the desired inductance is obtained and is then fastened under the fixing clamp. A fixing clamp is used for every type of inductor and has a twofold function: to earth the core and to improve the mechanical stability of the inductor.

Fig. 15 shows the dissipation factor tan $\delta = 1/Q$ as a function of frequency for the three types of inductor in the frequency range 20 to 500 kc/s. Each of the coils concerned has been designed so that its losses are lowest at 100 kc/s. It can be seen from the curves that at lower frequencies the dissipation factor, which is there largely determined by the ratio between the d.c. resistance of the winding and its inductance (i.e. R_0/L), is inversely proportional to the size of the coil. At higher frequencies (above the minimum of the dissipation factor) where the losses are mainly determined by losses in the ferrite, eddy current losses in the winding and self-capacity losses, the three types of inductor are more nearly equivalent. Fig. 16 shows the relationships for three

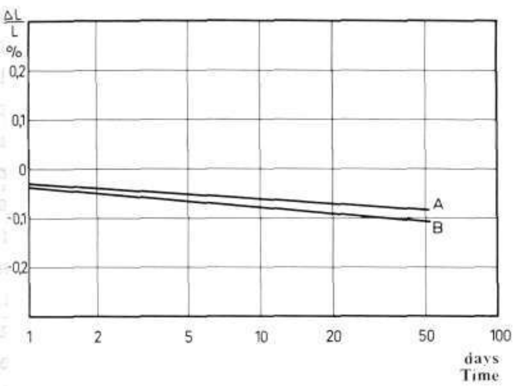


Fig. 14 X 2551

Change in inductance of a ferrite inductor with aging, by temperature cycling between + 55° and —20° C, as a function of the number of cycles

A for inductor without trimmer

B for inductor with trimmer

Fig. 15 X 2552

Dissipation factor tan δ as a function of frequency for three ferrite inductors

A, REG 101; B, REG 111; C, REG 112.

Fig. 16 X 2553

Dissipation factor tan δ as a function of frequency for three designs of ferrite inductor type REG 111

A Inductor designed for best Q at 500 kc/s

B Do. at 150 kc/s

C Do. at 25 kc/s

Fig. 15

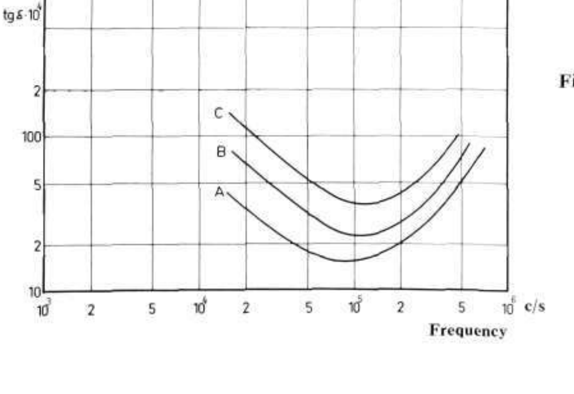
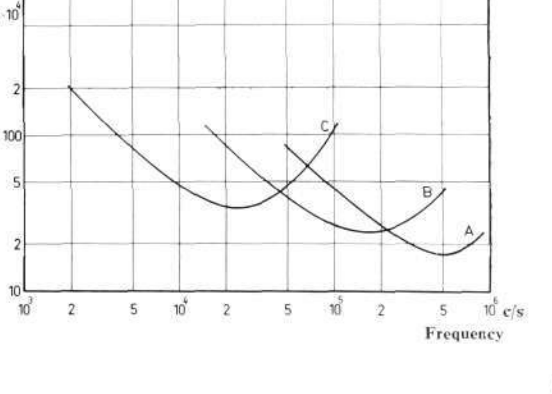


Fig. 16



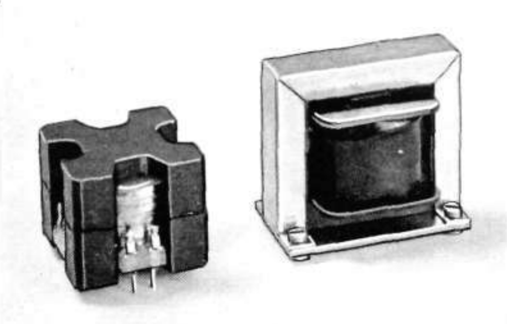


Fig. 17 X 2566

Ferrite transformer with X-core REG 301, and earlier type of transformer REK 131 using core of E-I laminations

different designs based on the same type of inductor, *REG 111*: these inductors have been designed for minimum losses at 25, 150 and 500 kc/s respectively by suitable choice of core material and air-gap. The curves show that maximum values of Q of 300, 400 and 600 respectively at the above frequencies can be obtained with this design.

Inductors with ferrite pot cores have a very low leakage field, i.e. they are magnetically self-screening, since the shape of the core is entirely closed and the permeability of the material is high. They can therefore be regarded as practically equivalent to toroidal inductors, and can be mounted as closely packed together as the mechanical construction allows without any separate screening between them, without giving rise to excessive crosstalk. These cores are considerably better than the pot cores made from iron dust used previously, in which the low permeability caused high leakage, thus making external screening of the inductors with sheet metal shields necessary, with resulting increased dimensions and losses.

Fig. 18 X 2563

Exploded views of ferrite-cored transformers

Transformers

In the same way as for inductors, ferrites used in transformers permit significantly reduced dimensions compared with earlier technique. Fig. 17 shows an earlier design, assembled with a laminated core, compared with a modern ferrite transformer whose volume is only 40 % of the other but nevertheless has a better performance.

Three sizes of transformer are used in the new construction for both audio and carrier frequency applications: these are shown in fig. 9, below. The smallest is assembled using conventional E-cores, but the two larger use an entirely new core shape called the X-core (Swedish patent No. 164 591). The simplicity of assembly of the transformers can be seen from fig. 18, which also shows the core shapes. The X-core uses the four corners of the square space it occupies as the return paths for the magnetic flux through the centre of the core. This constitutes a very favourable magnetic circuit comparable with that of a pot core, while at the same time the winding space extends to the outside edges of the core, which is not possible with the pot core. Due to the square form, good utilization of space is obtained when assembling units, so that even though the magnetic circuit is not entirely closed, the value of R_0/L obtained for an X-core is somewhat lower than that for a pot core occupying the same rectangular volume. A conventional E-I core for the same volume has about double the value of R_0/L compared with an X-core.

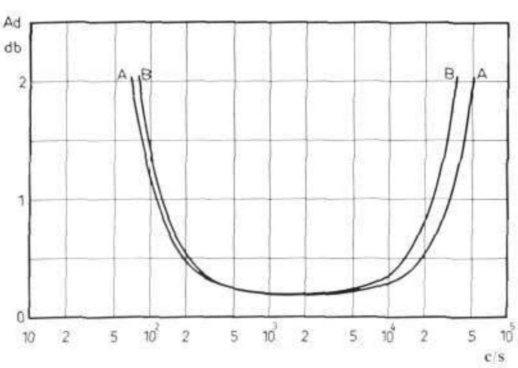


Fig. 19 X 2554

Loss as a function of frequency for two transformers designed for the same minimum loss

A Ferrite cored transformer REG 301
B Earlier type of transformer REG 231 (≈ REK 131)

Due to the more or less closed form of magnetic circuit in the X-core, the transformers have a low external leakage field; although not quite as low as for pot cores, nevertheless considerably lower than for E-I or similar cores. Thus crosstalk between two X-cores is about 15 db higher than between two pot cores but about 20 db lower than between two E-I cores, measured under similar conditions.

The compact assembly of the X-core results in a favourable relationship between primary inductance and leakage inductance, and this gives the transformer a large bandwidth. Fig. 19 shows the insertion loss as a function of frequency for two transformers, one designed with an X-core and the other with an E-I core. The same core material was used for both, and both have been designed for the same minimum loss in the band, about 0.2 db. It will be seen that the X-core covers a wider band, both at high and low frequencies, in spite of the E-I core having a volume 2½ times as large as the X-core.

These transformer cores, like pot cores, can be given an air-gap in their central limb. This is needed when the windings carry d.c. or when trans-

formers with close tolerances on inductance are required. Adjustment of inductance can be carried out by grinding the centre limb.

For comparing the performance of different transformers, it is convenient to define two quantities Q_2 and Q_σ as follows:

$$Q_2 = \frac{G}{l_m} \cdot \frac{1}{\sum \frac{l_{Fe}}{A_{Fe}}} \text{ and } Q_\sigma = \frac{1}{\mu \cdot \sigma} = \frac{3\, a_w/b_w}{l_m \sum \frac{l_{Fe}}{A_{Fe}}}$$

where G = winding space (cross-sectional area)
l_m = mean length of winding turns
A_{Fe} = cross-sectional area of the core
l_{Fe} = length of flux path in magnetic circuit
μ = relative permeability of magnetic material
σ = leakage factor for fully-wound transformer having two windings with no space between them
a_w = axial dimension of winding space
b_w = radial dimension of winding space

The quantity Q_2, which is proportional to L/R_0, is a measure of the transformer performance as regards minimum insertion loss: the quantity Q_σ is a measure of the transformer bandwidth. The quantity Q_2 depends on dimensions; if the same relative proportions are maintained, it increases with the square of the linear dimensions, i.e. as the two-thirds power of the volume. Q_2 and Q_σ for the three new transformers and for an earlier transformer with an E-I core are compared in table 1. This table also gives the various space requirements.

Table 1. Comparison between performance of different transformers.

Transformer type	Core type	Dimensions in mm			Volume cc.	Q_2 mm²	Q_σ
		l	w	h			
REG 203	E-E	27.5	22.5	23	14	0.7	0.100
REG 301	X	30	30	23	21	2.5	0.215
REG 302	X	40	40	23	37	3.6	0.166
REK 131	E-I	42.5	30	40	51	1.9	0.115

The smallest transformer has been included for applications where performance requirements are less exacting, and where the small space occupied and lower cost are of greater importance than performance.

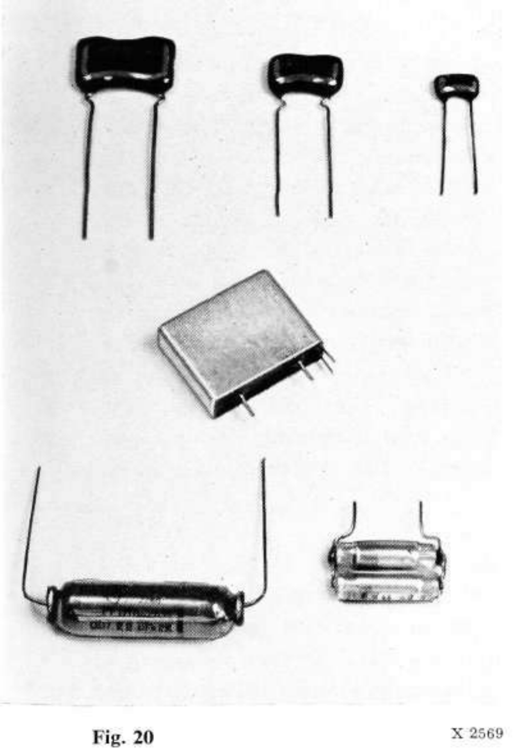


Fig. 20 X 2569

Mica capacitors (above) and polystyrene capacitors, in aluminium case, and (below) unprotected

Capacitors

Filter capacitors

Transmission technique has a great need of capacitors with low losses, close capacitance tolerances, good stability and temperature independence. It has long been the practice to use mica capacitors for this purpose, but for higher values they become large and expensive. By using a dielectric of plastic or ceramic, new types of capacitors can be made which can compete with mica capacitors for filter applications. In particular polystyrene is being used: polystyrene capacitors have been dealt with in an earlier article in Ericsson Review No. 2, 1954. Ceramic capacitors have up to now been used to a very small extent, since most ceramic capacitors manufactured today are intended for entertainment applications, where the demands on quality are not particularly high. Poor protection against moisture is especially troublesome, giving rise to problems with silver migration, capacitance instability and risk of short circuits.

The mica capacitors used in L M Ericsson's new transmission equipment construction are shown in fig. 20 (above): it will be seen that they are de-

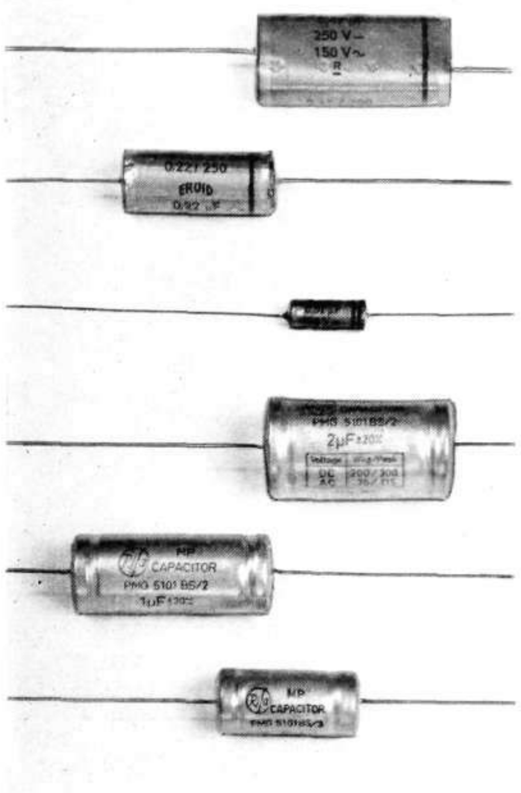


Fig. 21 X 2570

Epoxy resin impregnated paper capacitors (above) and metallized paper capacitors

signed for use with printed wiring. This type is a recent development and is very reliable. This reliability has been achieved by assembling the capacitor from silvered sheets of mica, impregnating with thermo-setting plastic, and finally coating with a special dipping varnish which gives a particular good protection from moisture.

Two different types of polystyrene capacitor are used, as shown (below) in fig. 20. The two capacitors at the bottom have no external case; the one in the centre has an aluminium casing filled with epoxy resin. Polystyrene capacitors exhibit very good capacitance stability and low dissipation factor; they have a negative temperature coefficient of about $140 \times 10^{-6}/°C$, which gives a fairly good compensation in filter circuits of the positive temperature coefficient of inductors. The unprotected polystyrene capacitors vary to some extent in capacitance according to the relative humidity of the surroundings: a capacitance increase up to about 1 % can occur. They are therefore only used in circuits where this capacitance drift can be tolerated without degrading circuit performance below acceptable limits. In any position demanding better capacitance stability under varying climatic conditions, the potted capacitors are used: their instability during prolonged aging tests has been found to be less than ± 0.2 %.

Paper capacitors

Two types of paper capacitor are used in L M Ericsson's new transmission equipment construction. One seen in fig. 21 (above), is built up like a conventional paper capacitor by winding two or three layers of paper with aluminium foil electrodes and connexion strips. However, to increase contact reliability at low operating voltages, the connexion strips are welded to the electrodes so that there is no risk of open circuits. In paper capacitors used previously, the connexion relied on contact pressure with the aluminium foil. An oxide layer can form over the foil and lead to an open-circuit if the a.c. operating voltage is too low to break down the oxide layer. It should be noted that even though the capacitor is maintained charged by a relatively high d.c. voltage, this does not result in any fritting of the points of contact.

The capacitor is impregnated with thermo-setting epoxy resin, which means that there is no liquid impregnating material: this epoxy plastic also acts as moisture protection. To increase the efficacy of protection against moisture, an aluminium foil layer is wound outside the capacitor proper and covered by the plastic. This considerably reduces the area of plastic through which water vapour can diffuse, leaving only the ends (where the plastic is comparatively thick) where moisture can get in. Fig. 22 shows the insulation resistance of a capacitor of 1,000 pF undergoing a damp heat test, in accordance with IEC publication No. 68, at + 55° C and 95–100 % relative humidity. It can be seen that the insulation resistance is practically unaffected by moisture after 20 days, and even after 100 days' testing the insulation resistance is still as high as 100 megohms. This value of capacitance, 1 000 pF, represents the lower limit of the range of values in which this type of capacitor is made, and since it has the most unfavourable surface/volume ratio, it is the most sensitive to moisture.

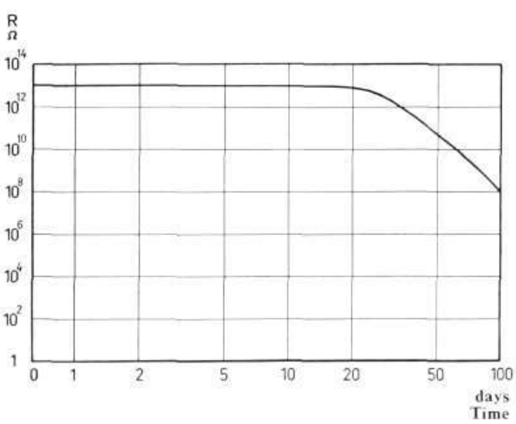


Fig. 22 X 2555

Insulation resistance of epoxy resin impregnated paper capacitor 1000 pF as a function of time during damp heat test at + 55 C and 95 —100 % RH

The epoxy-resin impregnated paper capacitor is equally as good from the point of view of breakdown voltage as paper capacitors with liquid impregnating substances, and superior to those types of capacitor with polyester foil as dielectric which have appeared on the market. It is also of simpler construction, and its independence of mechanical sealing, bushings through metal cases etc. make for better reliability against moisture.

The other paper capacitor used is a metallized paper type, shown in fig. 21, below. Here it has been possible to reduce dimensions considerably by covering

Fig. 23 X 2571

Electrolytic capacitors: above, with single hole fixing

the paper dielectric with a layer of metal produced by vapour deposition: this also gives self-healing properties in the event of a breakdown. Exhaustive investigations have succeeded in eliminating the risk of falling insulation resistance which often occurs with metallized paper capacitors when used at low operating voltages. The capacitor must of course have moisture protection: this takes the form of enclosing the rolled-up capacitor element in an aluminium tube whose ends are plugged with rubber and phenolic paper laminate. This technique is well established and can be used with very little risk of failure.

Electrolytic capacitors

The advent of the transistor, which works between low impedances, has increased the need for high values of coupling and decoupling capacitors. Previously electrolytic capacitors have mainly been associated with the entertainment field, where they have had a bad reputation as regards reliability–if a radio set was not functioning satisfactorily, one of the commonest troubles was a faulty electrolytic. The cause of failure in electrolytic capacitors was mainly open-circuits due to corrosion. This corrosion usually arose from the use of material containing impurities, of whose deleterious effects the manufacturer was unaware, and which could for instance eat away the internal connexion strips. For some years, however, most manufacturers have been well aware of the risk of corrosion and have taken precautions to ensure that the materials now used cannot cause failures of this kind. Nowadays it is very seldom that a failure of an electrolytic can be traced to attack by corrosion inside the capacitor.

But freedom from corrosion alone does not ensure long life and high reliability in an electrolytic capacitor. The commonest cause of limited life is now the risk of drying out, i.e. the semi-fluid paste electrolyte, which by its contact with the negative foil and the oxide layer of the positive foil forms one electrode, loses moisture by diffusion through the capacitor case and becomes dry. This loss of water by diffusion is of course proportional to the surface area of the case which is porous to moisture: hence for a low risk of drying out, the ratio of the capacitor's surface area to its volume should be small. This implies that one should avoid modern miniaturized components and instead use more conservatively dimensioned capacitors. Fig. 23 shows some examples of the electrolytic capacitors used in L M Ericsson's new transmission equipment construction.

To establish their degree of reliability, a number of capacitors were heat tested at three different temperatures $+40°$, $+55°$ and $+70°$ C with d.c. voltage applied. Fig. 24 shows their average values of capacitance as a function of time: from these curves it can be seen that a life exceeding 20 years should be obtained for equipment working at normal temperatures. Some suppliers already guarantee operation at $+40°$ C with less than 3 % failures for periods exceeding 130,000 hours.

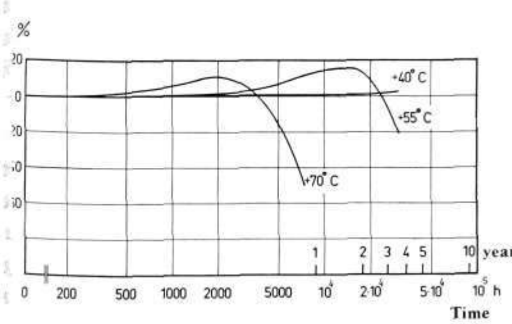


Fig. 24 X 2556

Capacitance of electrolytic capacitors as a function of time during heat aging with d.c. voltage applied

Electrolytic capacitors have latterly come to the fore using tantalum instead of aluminium. These are primarily of interest for use in military equipment, since they will withstand operating at high temperatures (up to $+125°$ C) but also work well in low ambient temperatures. There are three different patterns: the first has the form of a wound capacitor resembling a normal aluminium electrolytic, the second has a porous sintered and oxidized tantalum slug with sulphuric acid as electrolyte, while the third also has an electrode formed of such a tantalum slug but with a solid semiconductor in contact with the oxide layer, i.e. functioning as electrolyte.

Fig. 25 X 8258

Printed wiring card and contacts

The fact that tantalum capacitors have not been introduced on a larger scale in the new method of construction is partly due to their still being expensive and partly because their method of manufacture is still not yet in a settled state. We have found in our investigations that the failure rate is still not yet so low that they can be completely relied on, and certain unexplained phenomena occasionally occur.

Contacts

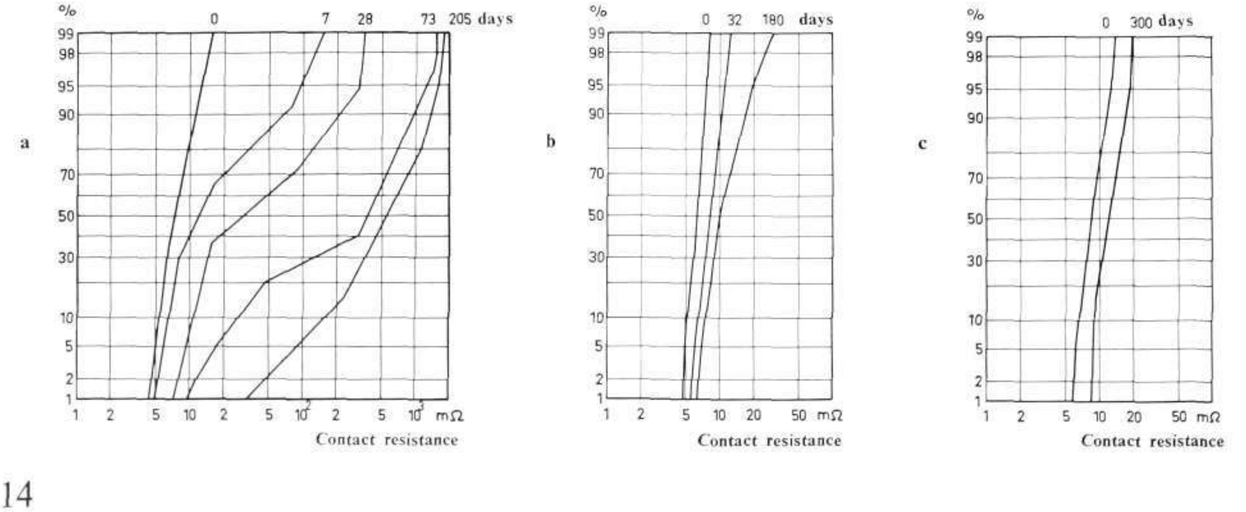
A transmission system includes many contacts and it is important that they all do their job, since an open circuit or a high contact resistance in a single contact point can jeopardize the operation of the entire link. Therefore a thorough study has been made of the design and characteristics of our contact devices. The mechanical construction has already been touched on in a previous article (see Ericsson Review No. 4, 1960, pages 119 and 124).

Fig. 26 X 2557 X 2564 X 2565

Distribution curves of variations in contact resistance after aging at + 70° C for various contact materials:

a) hard silver
b) silver palladium
c) gold

The commonest contacts are those which connect the unit printed wiring cards to the bay cabling: see fig. 25. The choice of material for these contacts is of the greatest importance for their reliability in operation. Fig. 26 shows how the contact resistance at one contact point varies with aging for three different contact materials. The ambient conditions chosen for aging were maintained at + 70° C, since repeated tests have shown that holding at



a raised temperature has a more unfavourable effect on contact resistance than, for example, moisture tests. Very low voltages and currents were used for measurement so that any oxide layer etc. formed should not be broken down. This corresponds to actual contact conditions for many applications in transmission technique. As will be seen, the stability of contact resistance for silver contacts is far from satisfactory, whereas contacts of silver-palladium alloy or gold are not significantly affected by aging.

The form chosen for the contacts is that of a contact strip bent round the edge of the wiring card, and fork-shaped contacts which each make contact with the strip at two points. The contact strip carries a layer of rolled gold which gets a very smooth fine finish from the rolling. The fork-shaped contacts are made from phosphor-bronze with an electrolytic hard gold plating. This results in the contacting surfaces having good resistance to wear. In order to raise the reliability still further, two fork contacts are used, giving a total of four contact points in parallel. Our investigations described above referred to a single contact point; due to the parallel connexion the total contact resistance will fall, and variations of contact resistance with time will be of no consequence.

Relays

The need for relays in transmission equipment is relatively restricted, but those relays which are used form especially important links. Two types of relays, perhaps the most reliable yet designed, have therefore been selected for this construction.

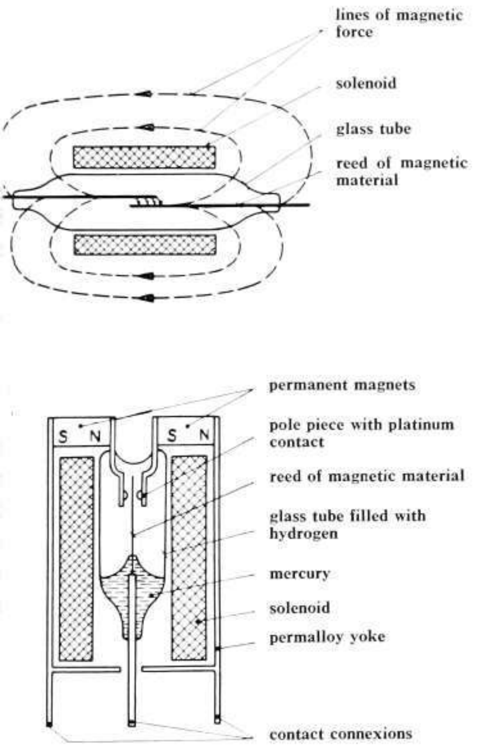


Fig. 27 X 2560

Schematic diagrams of a dry-reed relay (above) and a polarized relay with mercury-wetted contacts

Fig. 27 (above) shows the principle of the so-called "dry-reed" relay, developed in Bell Laboratories in the U.S.A. The contact springs are formed from two "reeds" of magnetic material sealed through the ends of a glass tube filled with gas. Contact material is plated on the ends of the reeds to form the contacts. One or more such contact tubes can be mounted in a solenoid: when current flows in this solenoid the reeds attract each other and make contact. This relay can operate mounted in any position. The sealing of the contact tube ensures good contact being obtained.

The other design of relay is shown in the lower half of fig. 27: this is also a Bell Lab. development. Here, too, it will be noted the contacts are sealed in a glass tube; a magnetic reed can change over between two sealed-in platinum contacts. Along the reed run capillary grooves which draw up mercury to the contacts. When these make contact they are wetted by the mercury, giving a perfect electrical junction. The relay is operated by a solenoid surrounding the glass tube. To increase the sensitivity, two permanent magnets have been included, thus giving a polarized relay. The glass tube is filled with hydrogen under high pressure, thus considerably reducing arcing and hence electrical erosion of the contacts.

The most important property of this mercury-wetted polarized relay is the high contact reliability. The relay is also fast in operation and has low contact noise, high sensitivity and high contact rating. Its only disadvantage–although quite without significance for stationary transmission equipment–is that it is affected by mounting position: it will only function when upright.

Private Automatic Exchange Type ARD 201 with Key Signalling

H BJÖRK, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

UDC 621.395.24
LME 8371

L M Ericsson has designed a private automatic exchange for requirements of 15 to 60 lines.

The switching equipment consists of crossbar switches and relays. These elements operate with extreme speed, are highly reliable, and require little maintenance. To make full use of the switching speed, the telephones are equipped with keyset instead of dial.

The exchange operates silently and can therefore be set up in any convenient location without causing disturbance.

The P.A.X. *ARD 201* (fig. 1) is of crossbar type with a capacity of 60 extensions and 8 connecting circuits. It consists of two units, each serving 30 extensions with 4 connecting circuits (figs. 2 and 3).

The trunking schemes for 30 and 60 extensions are shown in figs. 4 and 5.

The telephones are fitted with keysets. This gives quicker connection and is simpler than ordinary dialling. The numbers for 30 extensions run from *10* to *39* and for 60 extensions from *10* to *69*. The exchange caters for the following special facilities:

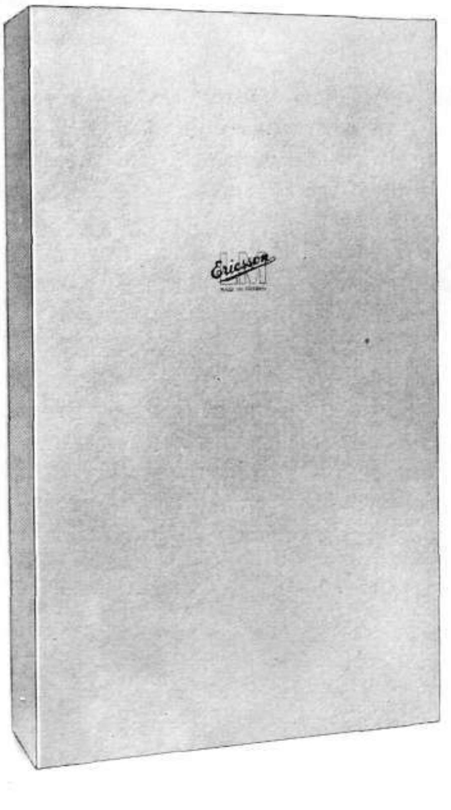
Priority
Paging via loudspeaker
Extra quick calls to 10 extensions

Fig. 1 X 2539

P.A.X. ARD 201 mounted on wall

Fig. 2 X 2540

Primary rack ARD 20101 (right)



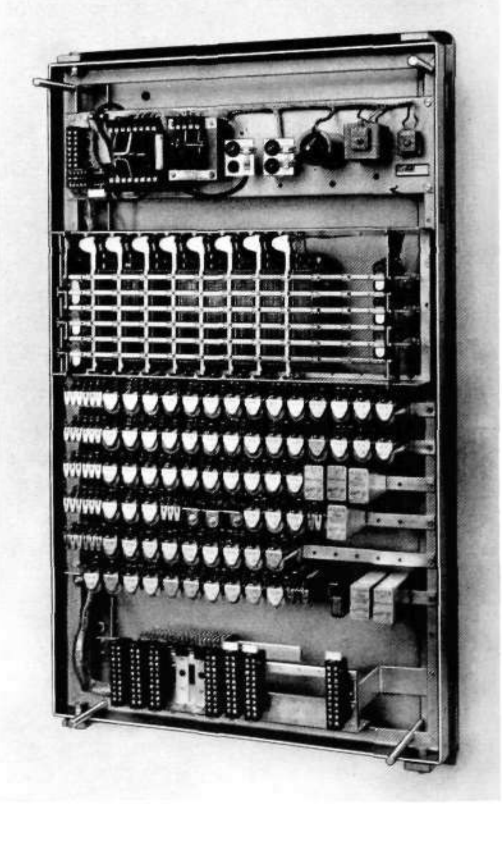
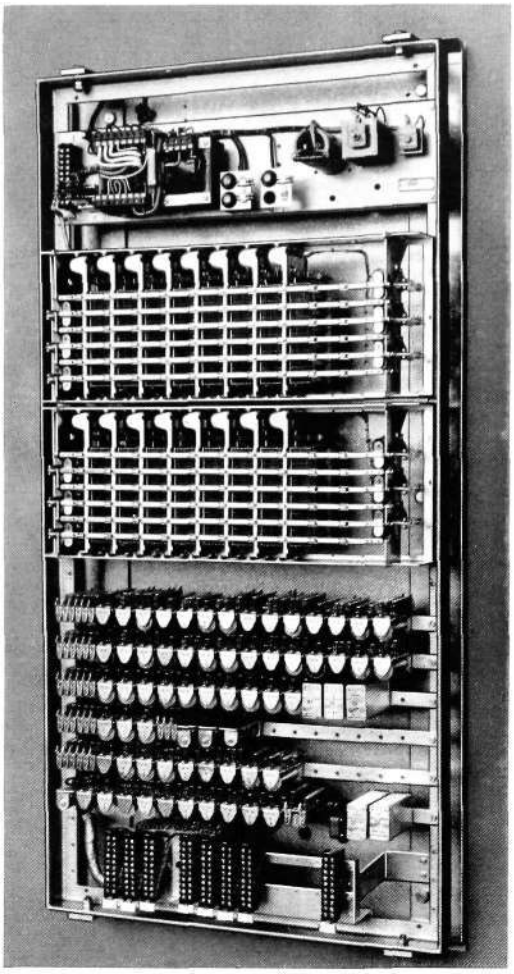


Fig. 3

Supplementary rack ARD 20102

X 2541



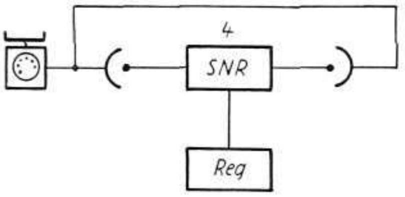


Fig. 4

X 2544

Trunking scheme for 30 extensions

SNR connecting circuits

Reg register

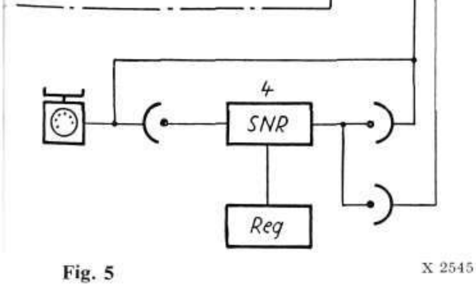


Fig. 5

X 2545

Trunking scheme for 60 extensions

Priority

The first 10 of each group of 30 extensions can be given priority. When a priority extension meets an engaged signal, connection with the engaged extension can be obtained by dialling *1*. The conversing parties hear a faint warning tone when the third party enters the line. The latter may either give a brief message and retire from the connection or may request the two parties to complete their conversation, whereafter the called extension is automatically signalled.

Paging via Loudspeaker

When this facility is desired, a special amplifier matching equipment is connected to an ordinary extension position. The keying of the paging number connects to this "extension" number and the caller is connected to the amplifier. He can then immediately announce the person's name or give a message which is broadcast over loudspeakers placed at appropriate positions in the premises.

Extra Quick Calls

Installed to full capacity the exchange numbering scheme runs from *10* to *69*; if only *one* group of 30 lines is installed, from *10* to *39*. Calls to nos. *11*, *22*, *33*, *44* etc. are made by pressing the same key twice. To enable as many

extensions as possible to be called by this simple operation, use has been made of nos. *00, 77, 88* and *99*, though lying outside the numbering scheme. They can likewise be used for *10* extensions even when only one 30-line group is installed.

Switchboard Structure

The equipment is mounted on two racks, each serving 30 lines. The racks are made for wall mounting and have a cover which can be locked. The switches and relays are placed on a hinged frame (fig. 6) so that the soldering side of the components can be reached without difficulty. Terminal blocks are provided for wiring between the racks.

Each rack contains equipment for jumpering.

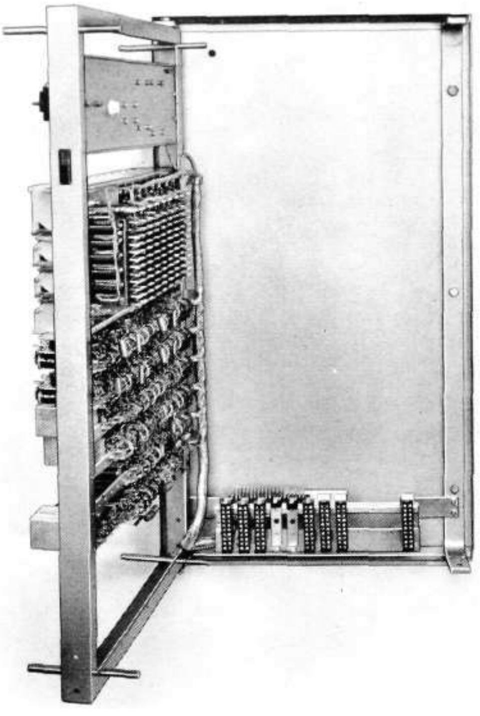


Fig. 6 X 2542

ARD 20101 with frame swung out

Power Supply and Signalling Equipment

Each group of 30 lines has a mains power unit with tappings for 110–220 V, 50–60 c/s. The exchange is designed to operate on 24 V, but variations between 20 and 30 V have no untoward effect. The alternating currents for ringing signals and keysending come from separate windings on the power unit transformer. Relays for generating the signal frequencies are placed in the primary rack. The length of signals can be adjusted as desired.

Telephones

The telephones have a set of twelve keys (fig. 7), ten of which are used for dialling. The remaining two keys can be used for service signals.

The keying system requires three-wire connection between telephones and switchboard. The third wire, which is at earth potential (d.c. positive pole), can be common to several telephones.

Telephone set *DBH 16301* has a knob on the bottom for adjustment of ringing signal strength.

Main Features

The crossbar P.A.X. *ARD 201* provides the following features:

- ☐ extra quick calls to ten extensions
- ☐ secret calls
- ☐ priority
- ☐ paging facility
- ☐ silent operation
- ☐ high reliability, so little servicing
- ☐ key signalling, which gives rapid and convenient connection.

Fig. 7 X 2543

Telephone set DBH 16301

New ALPHA Products

S JACOBSSON, AB ALPHA, SUNDBYBERG

UDC 621.979
LME 112

At the year end 1959 AB ALPHA, subsidiary of L M Ericsson, took over the manufacture of hydraulic presses and automatic scales previously conducted by AB Result in Stockholm.

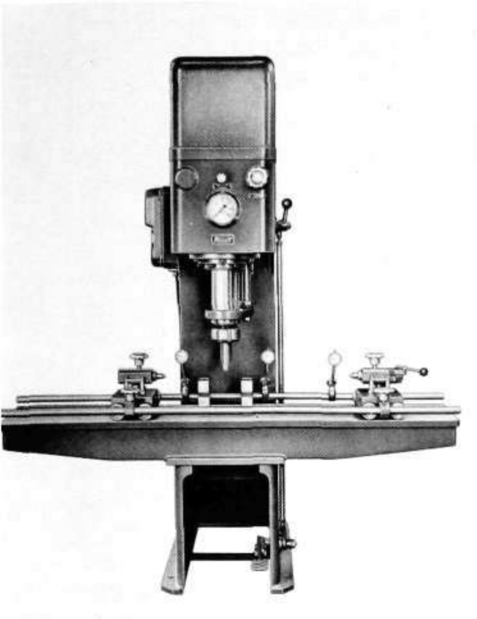


Fig. 1 X 2535

Gap press, Result type, specially designed for straightening work

Gap Presses

These types of press are made in several industrialized countries and are all fairly similar in their main features. The presses made by ALPHA have a maximum press force of 125 tons. They are chiefly used in engineering shops for *assembly, straightening, broaching* and *drawing work*. They can be equipped with ejectors, two-hand start, timing relay etc., and in this form can be used also for the powder industry.

Automatic Hydraulic Presses

The automatic hydraulic presses have their main applications in *powder compacting*. They are double-acting, pressing the powder both from above and below. This ensures greater density of the product, with less pressure than when using a single-acting press. The presses are equipped both for automatic charging of the powder into the die and for automatic ejection.

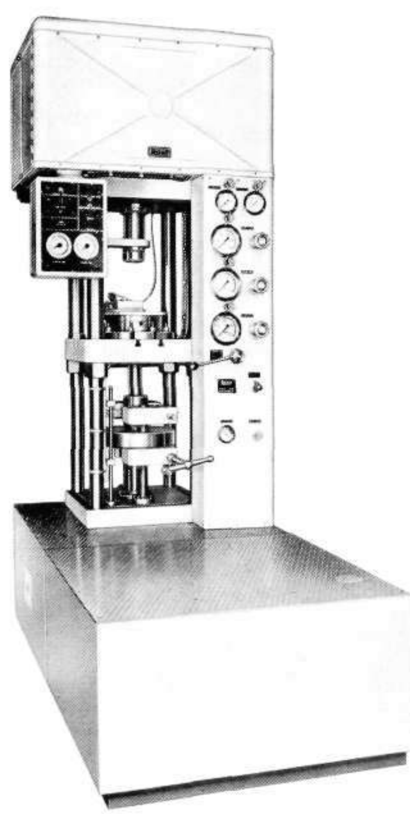


Fig. 2 X 2536

Automatic double-acting hydraulic press, Result type

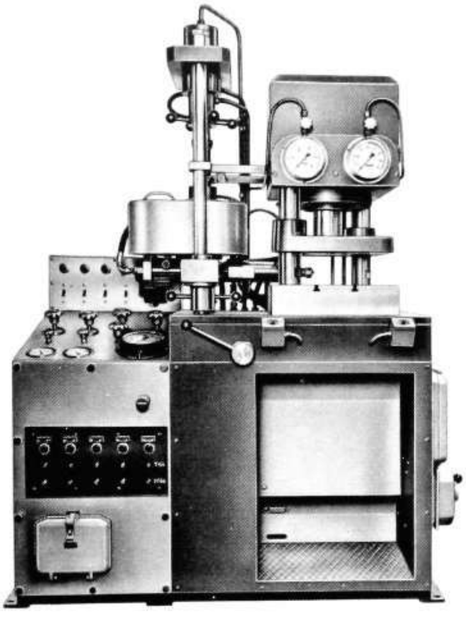


Fig. 3 X 2537

Wax injection press, Result type

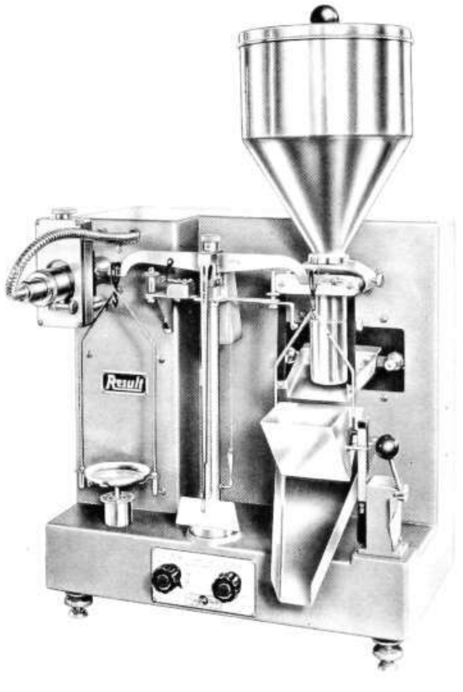


Fig. 4 X 2538

Photocell-controlled automatic scale, Result type

Charging can be done either on a volume or on a weight basis. In the latter case the press works in synchronism with automatic scales. If the material to be pressed is poisonous or radioactive, the tool space can be enclosed in a transparent plastic cover and cleaned out with a vacuum pump or filled with a conditioned atmosphere. This arrangement is employed for pressing uranium dioxide or plutonium for fuel elements in reactors. For compacting explosives (TNT, tetryl, hexotol), the entire press can be placed in a separate room and operated by remote control. Here, too, the press is fed from automatic Result scales. The control room is entirely shut off from the press room, so that the staff are fully protected against all risk of explosion.

Much trouble has been expended on the achievement of high output and of reliable and homogeneous charging of powders into dies of the most varying forms. Some of the feed arrangements are patented.

Automatic presses are made in sizes up to max. 130 tons press force.

Wax Injection Presses

The third line taken over from AB Result is wax presses for precision casting on the lost wax principle. The job of the press is to force the hard wax into a die. The usual procedure hitherto has been to use melted wax, which prolongs the solidification time and involves delay in removing the model from the die. In the ALPHA-Result press the wax is used in a plastic condition and forced into the die under high pressure. The machine itself controls the proper temperature of the wax. Accordingly the cold model can be put to immediate use; and rejects are rare, since the pressure guarantees complete filling of the die. This procedure gives a *three to four times higher output*.

Automatic Scales

The automatic Result scales are now made and sold by ALPHA. Being photocell-controlled, they weigh pulverized materials of different kinds with great accuracy and dispense them in the correct proportions. They can be used, for example, for apportioning powders as different as coffee, flour or gunpowder. As already mentioned, the scales can be synchronized with the automatic Result presses. This is done, for example, in the pressing of explosives which are charged to the press on a weight basis. The scales are made in two sizes, one for weights up to 250 grammes and a larger for up to 5 kg.

Deliveries

The number of press outfits of Result type now delivered is around 2,000. They are in service in practically all countries in Europe and South America, and in India and Egypt.

LM Ericsson Exchanges Cut into Service 1960

CITY EXCHANGES

Public exchanges with 500-line selectors

Town	Exchange	Number of lines
Argentine		
Tucumán	(extension)	7000
Bolivia		
Cochabamba	(extension)	1000
Brazil		
Aquidauana	(extension)	300
Astorga		200
Itaúna		500
Jataí		500
Maringá	(extension)	500
Piracicaba	(extension)	2000
Pirapora		300
São João del Rei		1000
São José do Rio Preto	(extension)	1000
Colombia		
Armenia	(extension)	500
Barranquilla	Estadio (extension)	2000
Cartagena	Centro (extension)	500
»	Bosque (extension)	500
Facatativa		600
Medellín area	Buenos Aires	5000
Neiva	(extension)	500
Salamina	(extension)	200
Ecuador		
Guayaquil	Centro (extension)	2000
»	Urdesa	500
Quito	Iñaquito (extension)	500
»	Mariscal Sucre (extension)	1000
»	Villa Flora	1000
Ethiopia		
Addis Ababa	Centro (extension)	1000
Finland		
Forssa	(extension)	500
Mikkeli/St. Michel	(extension)	500
Pieksämäki	(extension)	250
Pori/Björneborg	(extension)	500
Vaajakoski	(extension)	100
Iceland		
Akureyri	(extension)	500
Reykjavik	Grensås (extension)	2000
Italy		
North Italy		
Chioggia	(extension)	200
Este	(extension)	500
Legnago	(extension)	200
Monselice	(extension)	200
Oderzo	(extension)	100
Rovigo	(extension)	500
S. Bonifacio	(extension)	100
Treviso	(extension)	1000
Valdagno	(extension)	100
Venezia/Venice	Centro (extension)	1600
»	Lido (extension)	1000
»	Murano (extension)	200
Verona	(extension)	2000
Vicenza	(extension)	1000
South Italy		
Agrigento	(extension)	500
Alcamo	(extension)	200
Bari	(extension)	2500
Bari Carrassi		6500
Cassino	(extension)	100
Castellamare di Stabia	(extension)	500
Castellamare del Golfo	(extension)	500
Cosenza	(extension)	2000
Crotone	(extension)	800
Gela	(extension)	1000
Giarre Riposto	(extension)	760
Lecce	(extension)	2000
Mazara del Vallo	(extension)	500
Modica	(extension)	500
Molfetta	(extension)	1000
Napoli/Naples	Chiaia (extension)	6000
»	Miano (extension)	1000
»	Portici (extension)	2000
»	S. Giovanni	2500
»	Vomero I–II (extension)	1000
»	Vomero III	2000
Palermo	Calatafimi	3500
»	Ferrovia (extension)	4000
»	Libertà (extension)	4000
»	Mondello	600
Piano di Sorrento		600
Pompei		600
Salerno	(extension)	3000
Sora	(extension)	100
Sorrento		1000
Termini Imerese	(extension)	100
Torre Annunziata	(extension)	500
Lebanon		
Beirut	Centre (extension)	6000
»	Chiah (extension)	1000
»	Furn el Chebak (extension)	500
Saida		2000

Interior from 3000-line crossbar exchange at Padova, Italy, delivered by L M Ericsson.

X 7812

Town	Exchange		Number of lines
Libya			
Tripoli		(extension)	500
Mexico			
Jalapa		(extension)	500
México D. F.	Atzcapotzalco	(extension)	1000
»	Chuvubusco		3000
»	Morales	(extension)	1500
»	Peravillo	(extension)	500
»	Piedad	(extension)	500
»	Portales		4500
»	Sabino	(extension)	1000
»	Tacubaya	(extension)	1000
»	Valle	(extension)	1000
Puebla		(extension)	2000
Netherlands' West Indies			
Curaçao	Rio Canario	(extension)	500
Norway			
Arendal		(extension)	500
Bodö		(extension)	500
Fredrikstad		(extension)	1000
Halden		(extension)	500
Harstad		(extension)	500
Kristiansand S		(extension)	500
Lillehammer		(extension)	500
Narvik		(extension)	500
Rjukan			1800
Tromsö		(extension)	500

Town	Exchange		Number of lines
Panama			
Panama City	Panama 4	(extension)	500
»	Panama 5		2500
Peru			
Cuzco		(extension)	500
Tacna			1000
Poland			
Kraków		(extension)	4000
Sweden			
Bollnäs		(extension)	1000
Enköping		(extension)	1000
Eskilstuna		(extension)	3000
Göteborg/Gothenburg Suburban Area	Mölndal	(extension)	1500
»	Frölunda	(extension)	6000
Huskvarna		(extension)	1500
Jönköping		(extension)	1500
Karlskoga		(extension)	2000
Katrineholm		(extension)	1000
Kristinehamn		(extension)	1000
Köping		(extension)	500
Linköping		(extension)	2500
Ludvika		(extension)	1000
Lund		(extension)	2500
Norrköping		(extension)	5000
Nässjö		(extension)	1000

Town	Exchange	Number of lines
Stockholm Centre Area	Kungsholmen (extension)	2000
Stockholm Suburban Area	Handen (extension)	1000
»	Hanviken (extension)	1000
»	Huddinge (extension)	1000
»	Lidingö-Villastad (extension)	1000
»	Norrviken (extension)	500
»	Roslags-Näsby (extension)	1500
»	Råsunda (extension)	500
»	Spånga (extension)	2000
»	Tureberg (extension)	2000
»	Ulriksdal (extension)	2000
»	Viggbyholm (extension)	1000
»	Äppelviken (extension)	2000
Södertälje	(extension)	1500
Tumba	(extension)	500
Uddevalla	(extension)	2000

Town	Exchange	Number of lines
Uppsala	(extension)	2000
Värnamo	(extension)	1000
Västervik	(extension)	1000
Ängelholm	(extension)	1000
Örebro	(extension)	2000
Östersund	(extension)	500
Turkey		
Akhisar		1000
Aksehir		500
Ankara	Merkez Santral (extension)	2000
»	Yenişehir (extension)	2000
Çorum		500
Elazig		500
Izmir	Merkez Santral (extension)	3000
Kütahya		1000
Turgutlu		500
	Total	**209310**

Public exchanges with crossbar switches

Town	Exchange	Number of lines
Australia		
Toowoomba		6300
Brazil		
Brasilia		5000
Fortaleza	Aldeota	2000
»	Parangaba	600
Rio Claro		2000
Santa Barbara d'Oeste		600
Burma		
Rangoon	Maung Taulay (extension)	4000
»	Insein (extension)	300
Denmark		
Grenaa		1600
Horsens	(extension)	1000
København/Copenhagen	Birkerød	4000
»	Brøndbyøster (extension)	1000
»	Damsø (extension)	5000
»	Farum	2000
»	Glostrup (extension)	1000
»	Hvidovre (extension)	1000
»	Nærum (extension)	1000
»	Ryvang (extension)	1000
»	Sundbyøster	4000
»	Søborg (extension)	1000
Odder		1400
Struer		1200

Town	Exchange	Number of lines
Finland		
Helsinki/Helsingfors	Heikinlaakso/Henriksdal	840
»	Keskusta/Centrum (extension)	1000
»	Leppävaara/Alberga	1600
»	Meilahti/Mejlans (extension)	1000
Parainen/Pargas		1000
Tampere/Tammerfors		1600
Turku/Åbo		3000
France		
Perigueux[1]		4000
Ireland		
Dublin	Nutley	3000
Limerick	(extension)	600
Italy		
North Italy		
Padova		3000
Piove di Sacco		800
Venezia/Venice	Mestre	3600
South Italy		
Aversa		1200
Bagheria		1000
Carini		400
Castelvetrano		1000
Ischia		600
Locorotondo		400

[1] This exchange, system CP 400, was delivered by Société des Téléphones Ericsson, Colombes.

X 8253

Interior from crossbar exchange at Bizerte, Tunisia (see next page).

Public exchanges with crossbar switches (cont.)

Town	Exchange	Number of lines
Nicastro		800
Nola		800
Taormina		600
Sweden		
Karlskrona	(extension)	100
Ystad	(extension)	500
Tunisia		
Bizerte		1000
USA[2]		
Winter Park, Florida	(extension)	1000
North Madison, Indiana	(extension)	100
Elkin, North Carolina		1800
Galion, Ohio		600
Warren, Ohio		1500
Export, Pennsylvania	(extension)	350
Yugo-Slavia		
Beograd	Krunski Venac (extension)	2000
»	Zvezdara	2000
Bjelovar		800
Ljubljana	Centar	2000
Priština		1000
Sarajevo		1000
	Total	**94590**

[2] These exchanges, system NX-1, were delivered by North Electric Co., Galion, Ohio.

RURAL EXCHANGES

	Number	Number of lines[3]
Public rural exchanges with crossbar switches, system ARK, ART		
Ecuador	2	550
Finland	37	3760
Iceland	4	580
Italy	47	4080
Netherlands	3	2500
Sweden	—	700
USA[4]	18	3700
Yugo-Slavia	11	3800
Total	**122**	**19670**
Rural exchanges with 12-, 25- or 100-line selectors, system OL, XY		
Norway	**26**	**3960**

[3] The number of lines includes both new exchanges and extensions of existing exchanges.

[4] These exchanges system NX-2, were delivered by North Electric Co., Galion, Ohio.

TRANSIT EXCHANGES

	Number of junctions
Transit exchanges with crossbar switches, system ARK, ARM	
Denmark	3100
Finland	407
Iceland	120
Italy	2400
Mexico	100
Netherlands	1120
Total	**7247**

X 8254

2400-line transit exchange at Odense, Denmark, delivered by LM Ericsson.

Ericsson LM NEWS *from All Quarters of the World*

The inauguration of the Bizerte telephone exchange was attended by the Minister of the Tunisian P. T. T., Rachid Driss.

102,000 More Dial Lines for Egypt

L M Ericsson has signed a large new contract with the Egyptian telephone administration for the delivery and installation of automatic telephone exchange equipment.

The contract covers equipment for 102,000 lines: 60,000 for Cairo, 20,000 for Alexandria and 22,000 for thirteen other cities. All telephone exchanges are to be ready for cut-over before the end of 1965.

In November of last year a large contract was signed between the Administration and L M Ericsson for telephone exchanges for Cairo and five other cities in the Nile Delta to a value of 26 million kronor. Recently the Administration ordered 60,000 telephone sets for delivery from Sweden. The latest contract is a consequence of the Administration's decision to base its future telephone network exclusively on exchanges of L M Ericsson's modern crossbar switching systems, which in the past few years have won a secure footing on a large number of markets.

As mentioned in a previous issue of Ericsson Review, L M Ericsson had already undertaken to render engineering assistance to the organization in charge of the Egyptian Five Year Plan in the building of a factory which will manufacture telephone material in Egypt on licence. L M Ericsson has also engaged to train Egyptian technicians in conjunction with the deliveries of exchange equipment and the factory project.

Governor of Bizerte, Mohamed Ben Lamine, at inauguration of the city's new telephone exchange.

First Crossbar Exchange Opened in Tunisia

A 1000-line ARF exchange was opened at Bizerte, Tunisia, in October under ceremonious forms. Among those present were the Governor of Bizerte, Mohamed Ben Lamine, the Minister of the P.T.T., Rachid Driss, Chief Engineer Mohamed Mili, the Swedish Ambassador, Lennart Petri, and representatives of local government and of the P.T.T.

It was in July 1959 that L M Ericsson signed a contract worth 12.5 million kronor for additions to the telephone plant of the capital, Tunis. The earlier network consisted of 13,000 lines operating on two different automatic systems, which are to be replaced by 21,000 lines of Ericsson crossbar. In addition, 4000 dial lines are to be supplied for the suburbs of Tunis. This will make Tunis one of the most modern cities of the world as regards telephone communications.

A 2000-line ARF 10 exchange has also been ordered and is to be in service by the summer. The contract includes the building of a trunk exchange at Tunis with 85 national and 16 international positions. A 10-position trunk exchange has been opened at Bizerte.

Tunisian personnel are to be trained in the country as the installation proceeds. In addition, 25 Tunisian technicians are taking courses at the head offices in Stockholm. Two-fifths have already completed their studies, and a new group of five started work in January. Each group comes for a period of 4 months, both for theoretical study of the ARF, ARM and ARK systems and for practical exercises. The course ends with a couple of weeks training in telephone exchanges.

New Orders for L M Ericsson from Brazil

15,000 Lines for Brasilia

L M Ericsson has received additional orders for telephone exchange equipment for 15,000 lines for Brasilia, the new capital of Brazil, the telephone requirements of which are rapidly increasing.

At the inauguration of Brasilia in April 1960 the first 5000-line automatic exchange was opened in the Sul sector. This exchange is now to be extended by a further 5000 lines, which are expected to be in operation this year.

A new telephone exchange, "Centro", is to have automatic equipment for 10,000 lines. It will be accommodated in the headquarters building for the national telephone, radio and TV administration at present under erection in the centre of the city.

The contract also includes extension of the Brasilia trunk exchange by 80 operators' positions, bringing the capacity up to 106 positions.

Contracts with L M Ericsson for Brasilia, covering equipment delivered and on order, amount to close on 30 million kronor. This includes carrier terminal equipments for the radio links between Brasilia and Rio de Janeiro.

20,600 Lines for Recife

L M Ericsson has signed a contract for delivery of crossbar equipment for seven telephone exchanges serving 20,600 lines at Recife (Pernambuco) in Brazil. The contract was obtained by Ericsson's subsidiary, Ericsson do Brasil. Part of the equipment is to be manufactured at the L M Ericsson factory at São José dos Campos. Recife is the most important city of northern Brazil, with 600,000 inhabitants.

500-selector Exchange Opened in Lebanon

A new 2000-line exchange operating on L M Ericsson's 500-selector system was opened at the year end in the town of Saida in Lebanon. The inauguration ceremony, which was broadcast on radio and television, took place in the presence of the Prime Minister, Saeb Salam, and the Minister of Communications, Soleman Frangié. The first call was from the Prime Minister to the Governor of southern Lebanon. In a later conversation between the Prime Minister and the President Fouad Chehab, who was in Beirut, the latter congratulated Saida on its new exchange and expressed the hope of continued rapid automatization of the country's telephone network.

Prime Minister Saeb Salam cuts the symbolical tape at the inauguration of the Saida exchange. (Left) District Manager Ghazi Haidar, (right) Chief Engineer Maurice Ghazal. Between the Prime Minister and the latter is the Minister of Communications, Soleman Frangié.

Terminal Equipment for Sweden's Coaxial Network

The recently started delivery of Ericsson terminal equipment for a number of Swedish telephone exchanges represents an important step in the striving of the Swedish Board of Telecommunications to increase still further the capacity of certain coaxial cables. The contract was signed in the autumn of 1958, comprising supergroup, mastergroup and supermastergroup translation equipments with associated apparatus for generation of carrier frequencies. This equipment will bring up the capacity of the cables to 2700 telephone circuits per coaxial pair.

The first unit, comprising supermastergroup translation equipments and bays for carrier frequency generation on the Stockholm–Västerås–Örebro route, is now under installation. This is probably the first installation in the world of this type of equipment complying with the international recommendations. Behind it lies a quite unusual achievement. Development, design and production have been completed in just over 2½ years, of which period more than 600 manmonths were devoted to design. The entire project was made possible by intimate teamwork between technicians of the Board of Telecommunications and of L M Ericsson during the entire period, both in drawing up the technical specification, which had to be done with the greatest possible speed, and in maintaining continuous cooperation with the factory during the manufacture of the equipment.

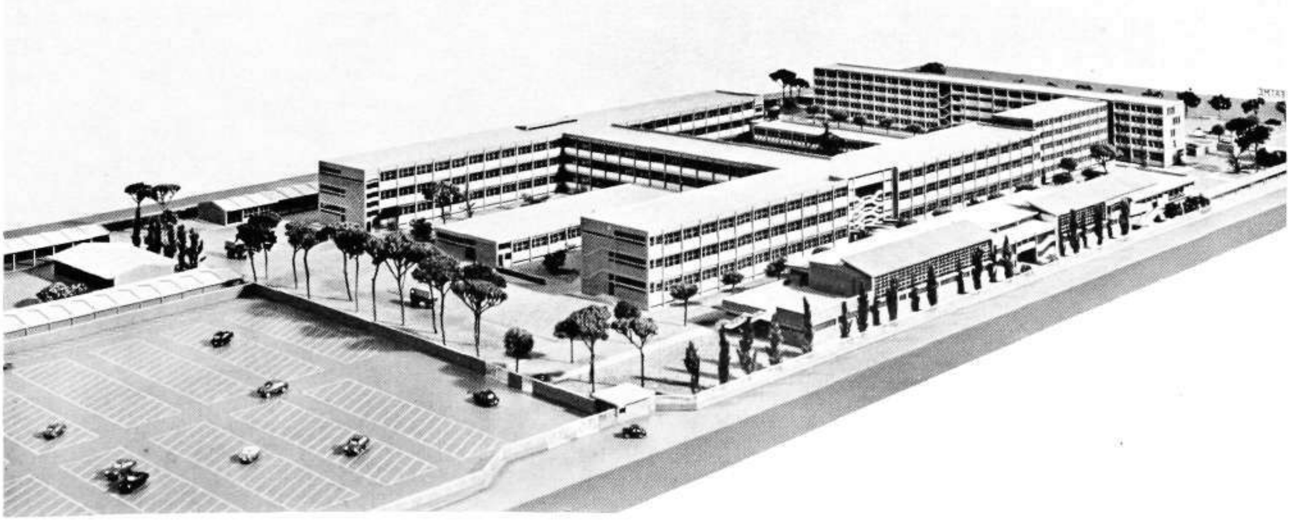
The design work was going ahead at the same time as a committee of C.C.I.T.T. was working out the international recommendations. This sometimes necessitated guessing the values and characteristics C.C.I.T.T. would arrive at. And in fact the delivery of the equipment occurred simultaneously with the announcement of the final recommendations by the plenary meeting of C.C.I.T.T. in Delhi.

Under the terms of the contract the remaining units are to be installed during the period 1961–1963, which will involve modifications of most of the large repeater stations in South and Central Sweden.

L M Ericsson's President S. T. Åberg and Vice President H. Lindberg were in the Argentine in December 1960. In the photograph below, taken during a visit to President Arturo Frondizi (far right), are seen, from left, Mr. Lindberg, Mr. Åberg, Mr. Vivaldi and Mr. S. Waltenburg, head of Cia Sudamericana de Teléfonos L M Ericsson S.A.

C. C. I. T. T., The International Telegraph and Telephone Consultative Committee, held its second plenary meeting at New Delhi at the end of last year, attended by representatives of administrations and telephone companies of 57 countries. L M Ericsson sent six delegates. Ericsson's Indian sales company gave a reception for the participants. In the photograph above are seen (from left) Mr. R. C. Vaish, head of the Indian delegation, the Swedish Ambassadress Alva Myrdal, H. Sterky, Director General of the Swedish Board of Telecommunications, B. Barkland, head of Ericsson Telephone Sales Corporation, New Delhi, and G. Svedhem of the Swedish Board of Telecommunications.

F.A.T.M.E., L M Ericsson's manufacturing company in Italy, is building a new factory. In the presence of Cardinal Fernando Cento, P. T. T. Minister Lorenzo Spallino, and the Swedish Ambassador, Erik von Post, the foundation stone was laid on November 24, 1960, in which a signed parchment scroll in Latin was immured. The photograph on the left shows Cardinal Cento during the ceremony with Minister Spallino (far left) looking on. Below: a model of the factory which is expected to be completed in 1963.



LM Ericsson Products at Buenos Aires Exhibition

At the year end Compañía Sudamericana de Teléfonos L M Ericsson S.A. (CSE) and other Ericsson companies in the Argentine took part in an industrial exhibition held at Buenos Aires in memory of the Declaration of Independence 150 years ago.

The official opening took place on December 20 in the presence of the Minister of Communications, Dr. Adolfo Mugica and other prominent persons. The photograph (left) shows the Minister making a trial call through a crossbar switchboard at the Ericsson stand. The other persons in the photograph are Sr. Utrero, technician, Mr. Berzins, Sr. Waltenburg, President of CSE, Sr. Cosentino, former Minister of Communications, and Sr. Aubone, Director General of the Telephone Administration.

Ericsson Technics No. 2, 1960

Ericsson Technics No. 2, 1960, has now appeared. In the opening article, "Transmission Performance in Presence of Circuit Noise", Fredrik Markman gives a survey of the work done hitherto in conjunction with questions under consideration by the C.C.I.T.T. concerning the influence of circuit noise of different kinds on transmission performance in international as well as intercontinental telephone circuits. Two types of test method are described, one based on articulation tests, the AEN method, and the other on opinions expressed by a large number of persons not normally concerned with telephonometric studies. AEN measurements have been made at the C.C.I.T.T. Laboratory at Geneva, and opinion tests have been conducted by a number of administrations, private operating companies and industrial organizations. The results are presented in the article.

In "Noise in a PCM Transmission System" by Henry Scheftelowitz the various sources of noise in a PCM transmission system are evaluated and their impact on the overall signal-to-noise ratio is calculated. Formulæ are given which show the signal-to-noise ratio in relation to repeater spacing.

The third article, "Signal Injection in Time Division Multiplex Systems with Resonant Transfer" by Dr. Walter Jacob provides information on some problems arising in time division multiplex systems with resonant transfer in connection with additional highway tuning. Two examples of signal injection in a two-wire and four-wire system are worked out. Finally some methods for generating suitable sinusoidal or composite signals are described.

A delegation from the Burmese state administration visited L M Ericsson's head offices at Midsommarkransen at the end of last year. (From left), Mr. E. Klingström, guide, Messrs. Than E, Thaung, Chan Tun Aung, C. E. W. Daniel, Khin Maung Maung and Win Pe.

UDC 621.395.44:621.3.04
LME 72, 73, 84

HARRIS, P O & HELLKVIST, N: *A New Method of Construction for Transmission Equipment. III. Electrical Components.* Ericsson Rev. *38*(1961): 1, pp. 2—15.

This article describes a selection of the most important electrical components used in L M Ericsson's new method of transmission equipment construction. Some of these components have been developed and are manufactured by L M Ericsson, others have been developed within the group but are manufactured by outside firms, while a third class, perhaps with a small turnover but nevertheless needing special equipment, is both designed and manufactured by outside firms. The construction of the components and their most important characteristics are described, especially those which have been a deciding factor in the choice of component type.

UDC 621.395.24
LME 8371

BJÖRK, H: *Private Automatic Exchange Type ARD 201 with Key Signalling.* Ericsson Rev. *38*(1961): 1, pp. 16—18.

L M Ericsson has designed a private automatic exchange for requirements of 15 to 60 lines. The switching equipment consists of crossbar switches and relays. These elements operate with extreme speed, are highly reliable, and require little maintenance. To make full use of the switching speed, the telephones are equipped with keyset instead of dial. The exchange operates silently and can therefore be set up in any convenient location without causing disturbance.

UDC 621.979
LME 112

JACOBSSON S: *New ALPHA Products.* Ericsson Rev. *38*(1961): 1, pp. 19—20.

At the year end 1959 AB ALPHA, subsidiary of L M Ericsson, took over the manufacture of hydraulic presses and automatic scales previously conducted by AB Result in Stockholm.

The Ericsson Group

Associated and co-operating enterprises

• EUROPE •

Denmark

L M Ericsson A/S *København F*, Finsens Vej 78, tel: Fa 6868, tgm: ericsson

Telefon Fabrik Automatic A/S *København K*, Amaliegade 7, tel: C 5188, tgm: automatic

Dansk Signal Industri A/S *København F*, Finsens Vej 78, tel: Fa 6767, tgm: signaler

Finland

O/Y L M Ericsson A/B *Helsinki*, Fabianinkatu 6, tel: A8282, tgm: ericssons

France

Société des Téléphones Ericsson *Colombes (Seine)*, Boulevard de la Finlande, tel: CHA 35-00, tgm: ericsson

Paris 17e, 147 Rue de Courcelles, tel: Carnot 95-30, tgm: eric

Germany

Ericsson Verkaufsgesellschaft m. b. H. *Düsseldorf 1*, Worringer Strasse 109, tel: 84 461, tgm: erictel

Great Britain

Swedish Ericsson Company Ltd. *London, W. C. 1*, 329 High Holborn, tel: Holborn 1092, tgm: teleric

Production Control (Ericsson) Ltd. *London, W. C. 1*, 329 High Holborn, tel: Holborn 1092, tgm: productrol holb

Italy

Setemer, Soc. per Az. *Roma*, Via G. Paisiello 43, Tel: 868.854, 868.855 *tgm*: setemer

SIELTE, Soc. per Az. *Roma*, C. P. 4024 Appio, tel: 780221, tgm: sielte

F. A. T. M. E. Soc. per Az. *Roma*, C.P. 4025 Appio, tel: 780021, tgm: fatme

Netherlands

Ericsson Telefoon-Maatschappij, N.V. *Rijen (N. Br.)*, tel: 01692-555, tgm: erictel

den Haag—Scheveningen, 10, Palacestraat, tel: 55 55 00, tgm: erictel-haag

Norway

A/S Elektrisk Bureau *Oslo NV*, P.B. 5055, tel: Centralbord 46 18 20, tgm: elektriken

A/S Industrikontroll *Oslo*, Teatergaten 12, tel: Centralbord335085, tgm: indtroll

A/S Norsk Kabelfabrik *Drammen*, P. B. 205, tel: 1285, tgm: kabel

A/S Norsk Signalindustri *Oslo*, P. B. Mj 2214, tel: Centralbord 56 53 54, tgm: signalindustri

Portugal

Sociedade Ericsson de Portugal, Lda. *Lisboa*, 7, Rua Filipe Folque, tel: 57193, tgm: ericsson

Spain

Cía Española Ericsson, S. A. *Madrid 4*, Conde de Xiquena 13, tel: 31 53 03, tgm: ericsson

Sweden

Telefonaktiebolaget L M Ericsson *Stockholm 32*, tel: 19 00 00, tgm: telefonbolaget

AB Alpha *Sundbyberg*, tel: 282600, tgm: aktiealpha-stockholm

AB Ermex *Solna*, tel: 82 01 00, *tgm*: elock-stockholm

AB Ermi *Bromma 11*, tel: 262600, tgm: ermibolag-stockholm

AB Rifa *Bromma 11*, tel: 26 26 10, tgm: elrifa-stockholm

AB Svenska Elektronrör *Stockholm 20*, tel: 44 03 05, tgm: electronics

L M Ericssons Driftkontrollaktiebolag *Solna*, tel: 27 27 25, *tgm*: powers-stockholm

L M Ericssons Signalaktiebolag *Stockholm Sv*, tel: 68 07 00, tgm: signalbolaget

L M Ericssons Svenska Försäljningsaktiebolag *Stockholm 1*, Box 877, tel: 22 31 00, tgm: ellem

Mexikanska Telefonaktiebolaget Ericsson *Stockholm 32*, tel: 190000, tgm: mexikan

Sieverts Kabelverk AB *Sundbyberg*, tel: 282860, tgm: sieverts-fabrik-stockholm

Svenska Radioaktiebolaget *Stockholm 12*, Alströmergatan 14, tel: 22 31 40, *tgm*: svenskradio

Switzerland

Ericsson Telephone Sales Corp. AB, Stockholm, Zweigniederlassung Zürich *Zürich*, Postfach Zürich 32, tel: 325184, tgm: telericsson

• ASIA •

India

Ericsson Telephone Sales Corporation AB *New Delhi 1*, P.O.B., 669, reg. mail: 1/3 Asaf Ali Road (Delhi Estate Building), tel: 28512, *tgm*: inderic

Bombay, Manu Mansion, 16, Old Custom House, tel: 254130 *tgm*: inderic

Calcutta, P. O. B. 2324, tel: 45-4494, tgm: inderic

Indonesia

Ericsson Telephone Sales Corporation AB *Bandung*, Djalan Dago 151, tel: 8294, tgm: javeric

Djakarta, Djalan Gunung Sahari 26, tel: Gambir 50, *tgm*: javeric

Lebanon

Telefonaktiebolaget L M Ericsson, Technical Office *Beyrouth*, Rue du Parlement, Immeuble Bisharat, tel: 252627, *tgm*: ellem

Thai

Erics…

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Turkey

Ericsson Türk Ticaret Ltd. Şirketi *Ankara*, Âdil Han, Zafer Meydani, Yenişehir, tel: 23170, tgm: ellem

Istanbul, Istanbul Bürosu, Liman Han, Kat 5, No. 75, Bahçekapi, tel: 228102, tgm: ellemist

• AFRICA •

Union of South Africa

L M Ericsson Telephone Co. Pty. Ltd. *Johannesburg*, 70, Loveday Street, tel: 33-2742, tgm: ericofon

Tunisia

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• AMERICA •

Argentine

Cía Sudamericana de Teléfonos L M Ericsson S. A. *Buenos Aires*, Casilla de correo 3550, tel: 332071, tgm: ericsson

Corp. Sudamericana de Teléfonos y Telégrafos S. A. *Buenos Aires*, Casilla de correo 3550, tel: 332071, tgm: cartefe

Cía Argentina de Teléfonos S. A. *Buenos Aires*, Perú 263, tel: 305011, tgm: cecea

Cía Entrerriana de Teléfonos S. A. *Buenos Aires*, Perú 263, tel: 305011, tgm: cecea

Cía Comercial de Administración S. A. *Buenos Aires*, Perú 263, tel: 305011, tgm: cecea

Industrias Eléctricas de Quilmes S. A. *Quilmes FCNGR*, 12 de Octubre 1090, tel: 203-2775, tgm: indelqui-buenosaires

Brazil

Ericsson do Brasil Comércio e Indústria S. A. *Rio de Janeiro*, C. P. 3601, tel: 43-0990, tgm: ericsson

São Paulo, C. P. 5677, tel: 36-6951, tgm: ericsson

Canada

Ericsson Telephone Sales of Canada Ltd. *Montreal 8, Que.*, 130 Bates Road, tel: RE 1-6428, tgm: caneric

Toronto 18, Ont., 34 Advance Road, tel: BE 1-1306

A.

tel:

…ago-

dechile

Colombia

Cía Ericsson Ltda. *Bogotá*, Apartado Aéreo 4052, tel: 41-11-00 tgm: ericsson

Ecuador

Teléfonos Ericsson C. A. *Quito*, Casilla Postal 2138, tel: 33777, tgm: ericsson

Mexico

Cía Comercial Ericsson S. A. *México D. F.*, Apartado 9958, tel: 46-46-40, tgm: coeric-mexico

Industria de Telecomunicación S.A. de C.V. *México 6, D.F.*, Calle Londres No 47, Colonia Juárez, tel: 250405, tgm: industel

Peru

Cía Ericsson S. A. *Lima*, Apartado 2982, tel: 34941, tgm: ericsson

Soc. Telefónica del Perú, S. A. *Arequipa*, Casilla de Correo 112, tgm: telefonica

El Salvador

Telefonaktiebolaget LM Ericsson, Technical Office, *San Salvador*, Apartado Postal 188, tel: 4989, tgm: ericsson

Uruguay

Cía Ericsson S. A. *Montevideo*, Casilla de Correo 575, tel: 9-26-11, tgm: ericsson

USA

The Ericsson Corporation *New York 17, N. Y.*, 100 Park Avenue, tel: Murray Hill 5-4030, tgm: erictel

North Electric Co. *Galion, Ohio*, P. O. B. 417, tel: Howard 8-2420, tgm: northphone-galionohio

Venezuela

Cía Anónima Ericsson *Caracas*, Apartado 3548, tel: 543121, tgm: ericsson

Teléfonos Ericsson C. A. *Caracas*, Apartado 3548, tel: 543121, tgm: tevela

• AUSTRALIA & OCEANIA •

Australia

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Agencies

• EUROPE •

Belgium

Electricité et Mécanique Suédoises *Bruxelles 5*, 56 Rue de Stassart, tel: 11 14 16, tgm: electrosuede

Greece

»ETEP», S. A. Commerciale & Technique *Athens*, 11, Mackenzie King Street, tel: 617041, tgm: aeter-athinai

Ireland

Communication Systems Ltd. *Dublin*, 40, Upper Fitzwilliam Street, tel: 61576/7, tgm: crossbar

Iceland

Johan Rönning H/F *Reykjavik*, P. O. B. 45, tel: 14320, tgm: rönning

Yugo-Slavia

Merkantile Inozemna Zastupstva *Zagreb*, Pošt pretinac 23 tel: 34770, tgm: merkantile, telex: 02-139

• ASIA •

Ceylon

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CONTENTS

On cover: In the exhibit hall at L M Ericsson's main factory in Midsommarkransen, Stockholm, the many different products manufactured in the concern are presented.

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Transistorized Channel Modulating Equipment for Carrier Terminals

S-O JOHANSSON & B RASK, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

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621.376.6
LME 8421, 7544

This channel translating equipment is made according to L M Ericsson's new design principles for transmission equipment, as described in earlier numbers of Ericsson Review. The present article describes the equipment, giving reasons for the adoption of certain techniques. Performance data are given and various applications of the equipment in carrier system terminals are described.

The first modulation equipment in all modern carrier systems, from a 12-circuit to a 2 700-circuit system, consists of a channel modulation equipment – that is, the equipment which translates speech channels at voice requency into basic groups of 12 channels. The frequency band of 60–108 kc/s, with the channel frequency bands inverted, has been standardized by CCITT as "basic group B". It is this band which in normally used in building up larger carrier systems. It also permits flexible through-connexion arrangements on a group basis between different systems.

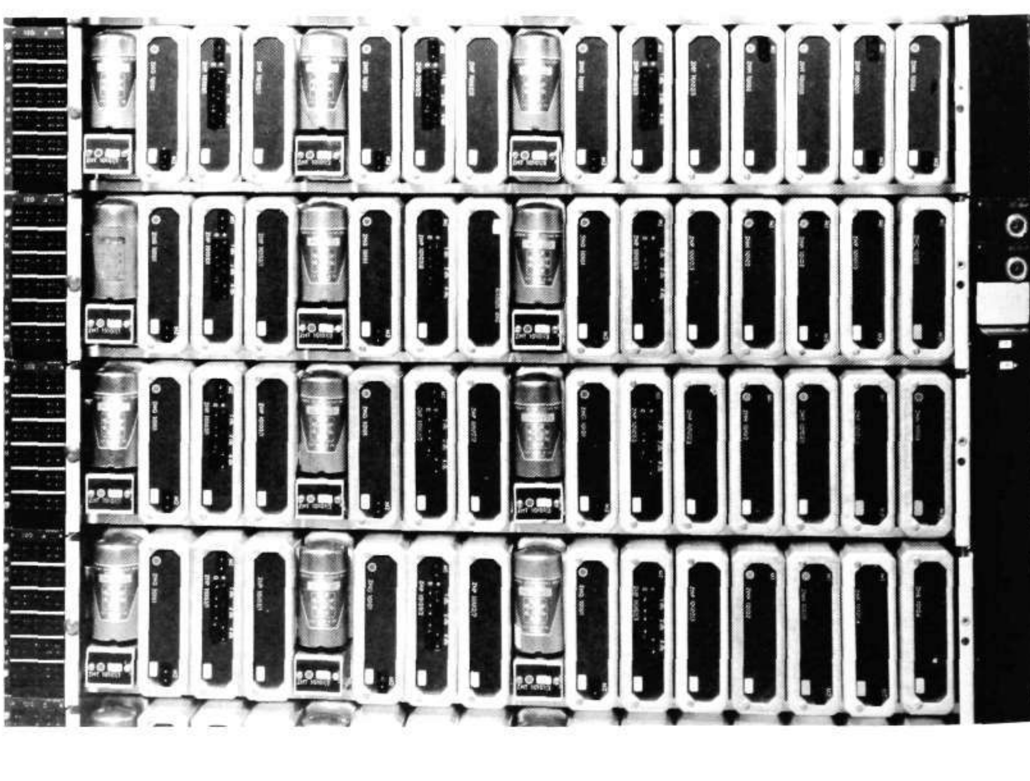
I. System Arrangement

The channel modulation equipment was one of the first designs to use the new L M Ericsson construction principles for transmission equipment. It is in principle built up of a number of functional units using printed wiring and modern miniature components. For amplification, transistors are used exclusively. The arrangement of the units for a single group may be seen from fig. 1. Further details of the new L M Ericsson construction principles may be found in Ericsson Review 1960, No. 4, "A New Method of Construction for Transmission Equipment".

Fig. 1 X 7820

Assembly of equipment for one group

The group shown is provided with out-band signalling. The units with a design differing from the remainder are the signalling receivers, having the signalling relay at the front.



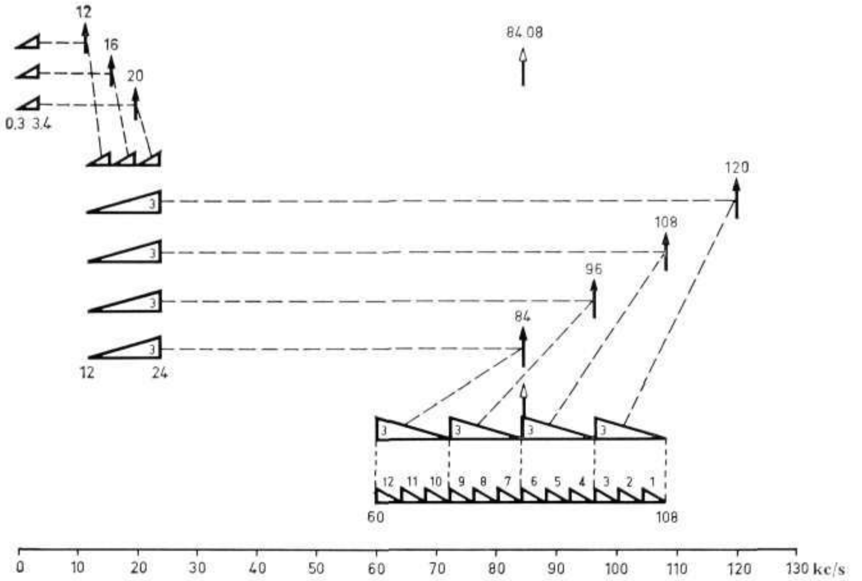


Fig. X 8261

Modulation plan for channel translation

The modulation scheme for channel translation uses two stages of modulation as shown in fig. 2. Modulation in two stages rather than one has been chosen because it was found to give lowest manufacturing costs with present manufacturing techniques and available components.

The channel translating equipment can be adapted by means of plug-in pads to the levels used by most telephone administrations at their distribution frames for both speech and group frequencies.

Furthermore the group side can be matched to different impedances now in use (75, 135 and 150 ohms).

The channel translating equipment can be provided with various types of signalling facilities, either in-band or out-band.

To facilitate maintenance, the channel translation equipment has been provided with test points and U-links in accordance with a carefully thought-out plan. The test points are classified in two categories, viz. those for routine maintenance measurements and those for fault location. The routine test points are placed at the beginning and end of each complete block of equipment for a group. Test points which are concerned with 12 or more channels have been made "short-circuit proof", *i.e.* a short-circuit at the test point is not allowed to degrade the transmission path performance. These test points are furthermore insensitive to the impedance presented by the termination in the transmission path.

Fault-finding points are provided on the units themselves and permit localization of a fault to a particular unit. U-links are so placed that they allow a system to be spilt up into its various sections – in this case, at the channel and group inputs and outputs.

II. Modulation Equipment

A block diagram of the modulation equipment is given in fig. 3.

Sending Direction

The incoming band of speech frequencies passes the channel U-link and is attenuated in a pad to the system input level -14dbr. The voice frequencies are modulated in the respective channel modulators onto carriers of 12, 16 or 20 kc/s, and the upper sidebands are selected in the subsequent band-pass filters, after which they are brought together to form a subgroup.

The subgroups so formed are fed to their respective subgroup modulators via a hybrid transformer, whose other branch can be fed with signalling tones in the subgroup band. After modulation in the subgroup modulator, the lower sideband is selected in the subsequent band-pass filter. The four subgroups in their appropriate frequency ranges are brought together in the sending subgroup hybrid transformer, whose primary winding is a symmetrical differential winding. The secondary is also symmetrical and is used for injection of the 84.08 kc/s group pilot; this thus occurs directly after assembly of the group. Injection by means of a hybrid is necessary here because the subgroup filters do not present a correct termination at this frequency. The group so formed is amplified in the group amplifier, which is completely transistorized 3-stage amplifier. The amplifier output transformer has an asymmetric differential winding which is used to derive the maintenance test point.

The outgoing group, with a nominal level of -26 dbr, leaves the equipment via a U-link.

Receiving Direction

The level of the incoming group is normally -8 dbr. This is reduced to the equipment input level of -14dbr in a U-link with a built-in pad. The group passes to the receiving subgroup hybrid transformer.

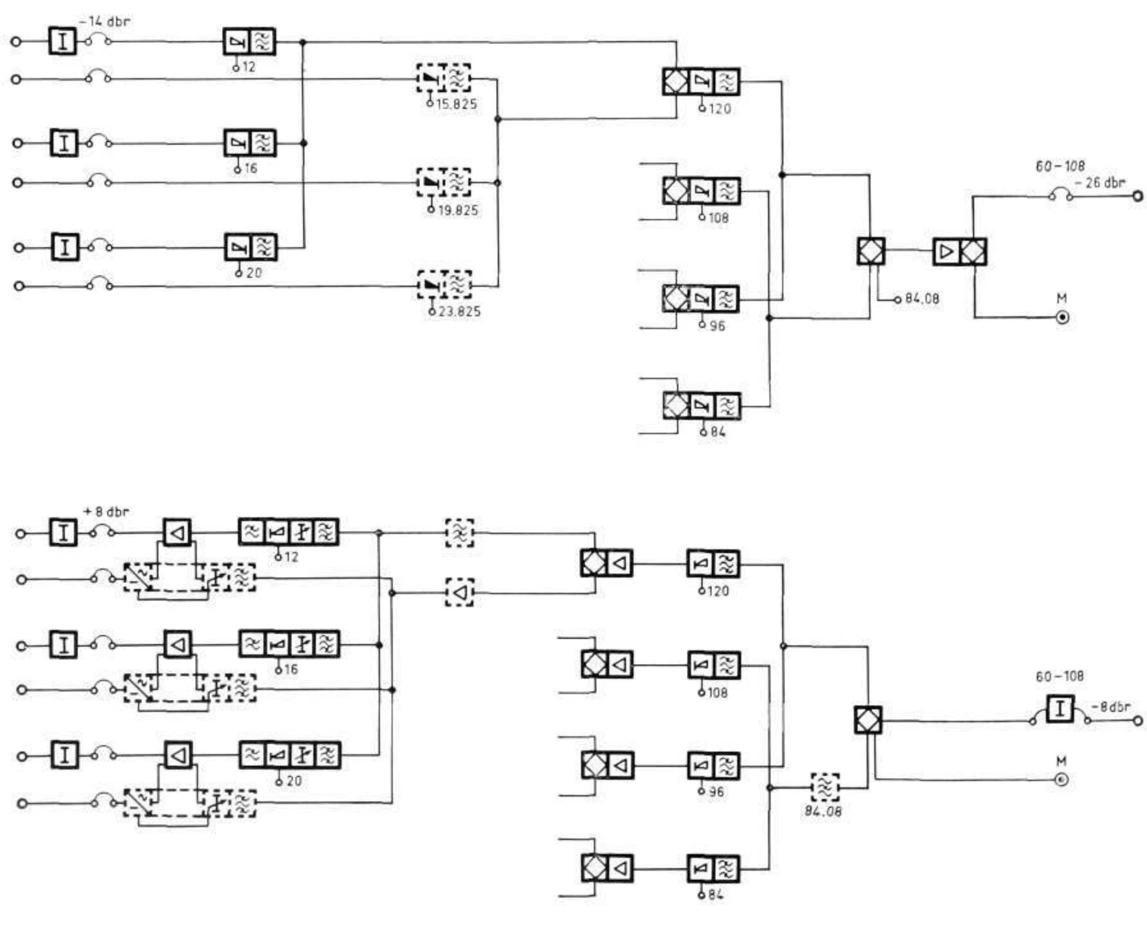
The primary winding of this transformer is unsymmetrical, and is used to couple in the maintenance test point. The symmetrical secondary winding distributes the various subgroups to the demodulator filters.

Where low level out-band signalling is used, the 84.08 kc/s pilot must be suppressed by a crystal filter in order not to interfere with signalling.

Fig. 3 X 7813

Block schematic of channels translating equipment

The blocks with dashed outlines indicate equipment for low-level out-band signalling.



After demodulation in its subgroup demodulator, each subgroup is amplified in a two-stage transistorized subgroup amplifier having a low-pass filter at its input. This filter attenuates the carrier leak and upper sideband from the subgroup demodulator so that no overloading of the subgroup amplifier occurs. The amplifier output transformer is an unsymmetrical hybrid, the speech output being taken from one arm and the other being terminated in a resistor. Where outband signalling is used, the signals are taken out across the balance arm.

The bands of speech signals thereafter pass through a signalling blocking filter – only used in conjunction with outband signalling – and are separated by the band-pass filters of the channel demodulators.

After demodulation the voice frequencies are amplified in a channel amplifier, at whose output the level is +8dbr.

The channel amplifier, a two-stage transistor amplifier, can amplify frequencies up to 24 kc/s; it can thereby also be used for amplifying signalling frequencies in the subgroup range, either in-band or out-band. As on the sending side input, there is at the output a U-link and pad for level adjustment.

Channel Modulation Equipment

The channel modulator, besides being used for modulating, also functions as a limiter for the incoming speech level, thereby helping to prevent overloading of amplifiers in later stages and also interference with possible out-band signalling.

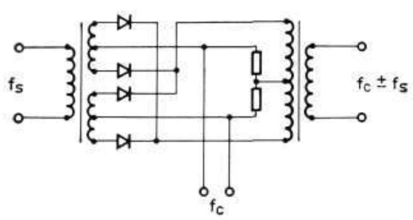


Fig. 4 X 2577

Schematic circuit of modulator

The modulator circuit, used throughout the channel translating equipment for both modulation and demodulation, is of the double balanced type with germanium diodes. Fig. 4 gives the circuit diagram of this modulator. The characteristic feature of the circuit, which is an L M Ericsson patent, is that seen from the source of carrier frequency the two pairs of diodes are connected in series. This type of modulator gives the possibility of choosing the optimum working point so that current and voltage limiting occur simulaneously. This gives the channel modulator a good limiting action while at the same time the harmonic distortion before limiting starts is low, *i.e.* the linearity is good. A typical limiter characteristic is shown in fig. 5.

Another of the advantages of this modulator is that it is economical of carrier power: the consumption is less than half that for an ordinary ring-type modulator. The low carrier power in the modulator contributes to the fact that carrier leak is significantly lower. This is necessary since the low-level out-band signalling system places much more severe requirements on carrier leak than

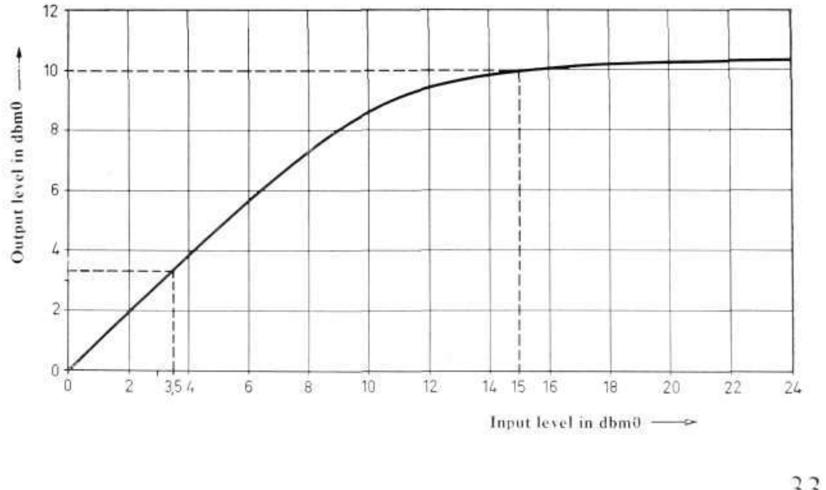


Fig. 5 X 8262

Limiting characteristic for channel modulator

The dashed lines refer to limiting and linearity specifications.

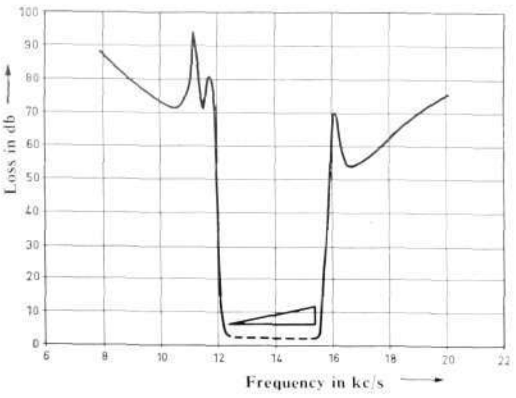


Fig. 6 X 2572

Attenuation of sending channel filter

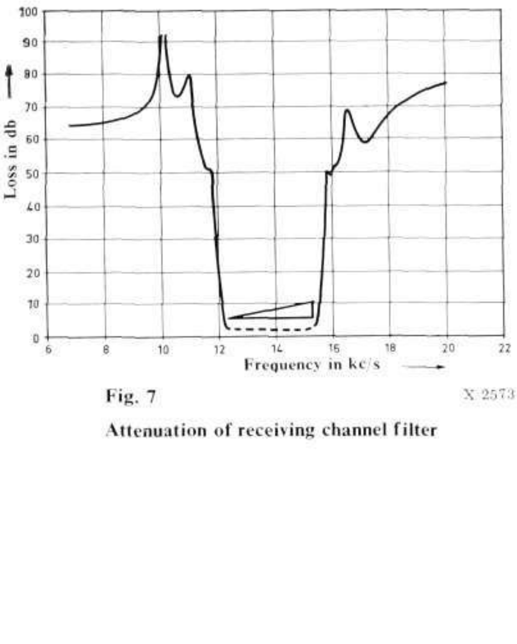


Fig. 7 X 2573

Attenuation of receiving channel filter

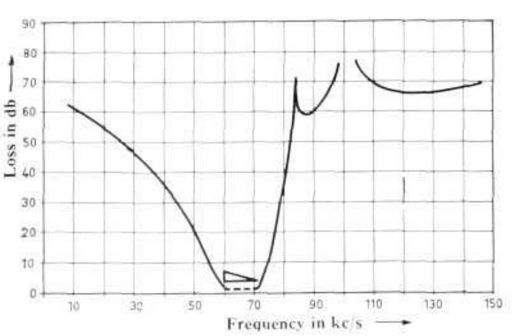


Fig. 8 X 2574

Attenuation of subgroup filter

those originally envisaged by CCITT (-17 dbm0 per channel). This limit was fixed on the basis of system loading. Using out-band signalling the carrier leak is only 175 c/s away from the signal and can easily interfere with it. The new channel translating equipment has been designed so that no channel carrier leak in an outgoing group shall exceed -28 dbm0. It has proved necessary to keep the leak so low, since the leaks in higher modulation stages can add to the channel carrier leak to give excessive interference levels in the signalling receiver.

The attenuation of the unwanted sideband in the sending and receiving channel filters is sufficient to give good suppression of interference from adjacent channels due to speech or signalling frequencies in commonly used signalling systems, for instance

out-band signalling 3 825 c/s, high or low level
1-VF in-band signalling 500–3 000 c/s
2-VF in-band signalling 2 040/2 400 c/s
multifrequency code inter-register signalling 500–2 000 c/s.

Since the attenuation requirements set by these signals are usually more severe than for speech, the filter performance is determined by them. Crosstalk attenuation is therefore very good. The stop-band attenuation of the sending and receiving channel filters can be seen from figs. 6 and 7 respectively.

The channel demodulators are followed by a low-pass filter with high attenuation for the 3 825 c/s out-band signal and for carrier leak, which otherwise might disturb measurements in the channel or be troublesome for tandem connexions. The curves just mentioned include the effect of this low-pass filter. The three channel filters are paralleled using L-pads.

The level of each channel in the outgoing group can be raised 1 db by means of a soldered strap connexion in the channel modulator so as to be able to compensate for possible aging of the modulator diodes.

Since the frequency response in an incoming group may not be flat, for instance when several through-group connexions occur, individual adjustment of the output level of every channel has been provided. The range of adjustment is from +4 db to −3 db relative to the nominal level, in steps of 1 db. This is effected by U-link plugs readily accessible on the front of the channel demodulator.

Subgroup Modulation Equipment

The subgroup modulators and their filters are identical with the corresponding demodulators.

The modulator circuit is the same as that used for channel modulation. Here the linearity requirement is much more severe: hence the difference between carrier and relative transmission level has been made higher, and some linearization of the modulator has been included.

The subgroup band-pass filters are computed for a minimum of components and with a high degree of compensation of the effect of losses, in order to met the requirement for frequency response over the band.

The various filters function independently of each other, so that where a group is only partly equipped, no dummy filters are needed.

The different types of subgroup filter all have a similar frequency response: a typical characteristic is shown in fig. 8.

The interconnexion of the filters is effected by symmetrical hybrid transformers both on the sending and receiving sides.

III. Signalling Equipment

The channel translating equipment can be provided with the following types of signalling equipment –

Out-band signalling, low level
» » , high level
1–VF in-band signalling
2–VF » »

The equipment for out-band and 1-VF in-band signalling is "built-in" as an integral part of the channel translating equipment, *i.e.* the signalling is operated over separate signal wires both on the sending and receiving sides. For 2-VF in-band signalling, only the receiving equipment is a built-in part of the channel translating equipment.

Out-band Signalling, Low Level

This type of signalling is effected with an equivalent channel frequency of 3 825 c/s and a level of -18 dbm0.

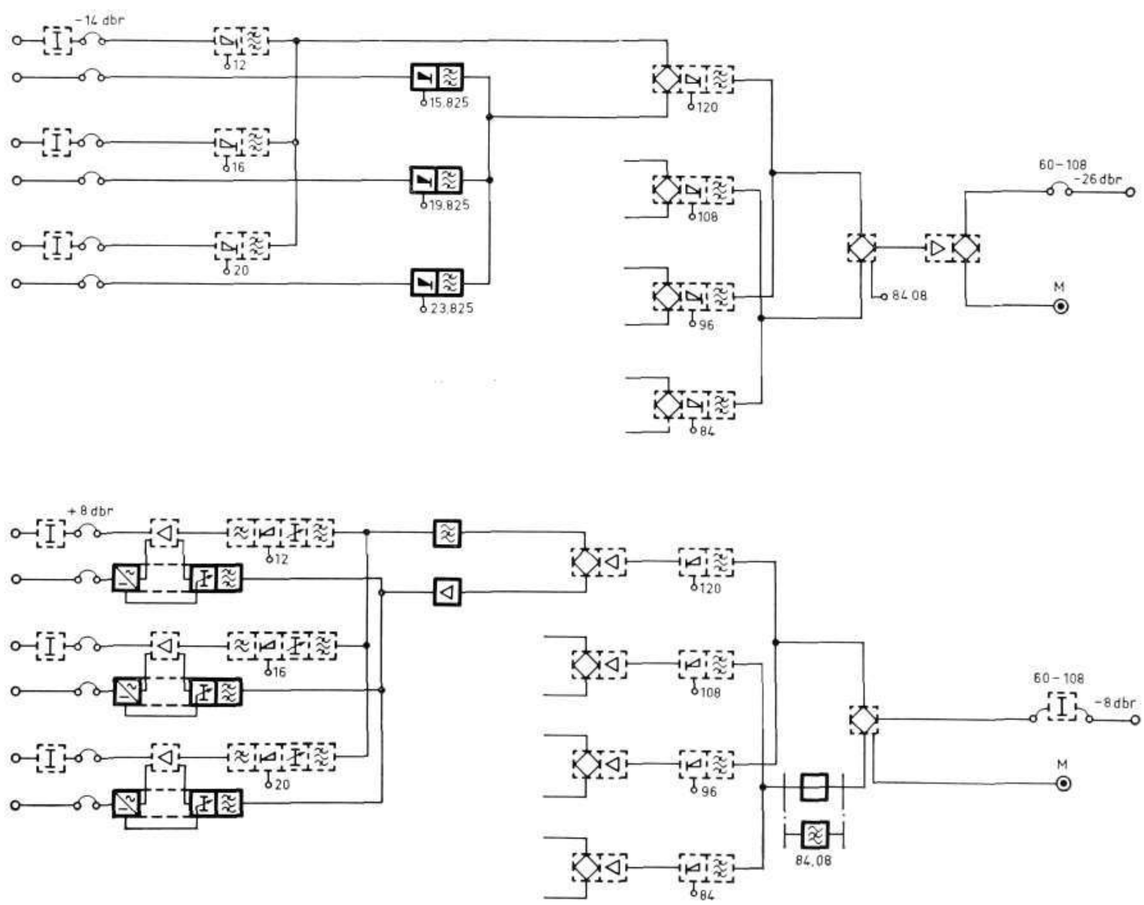
A block diagram of the signalling equipment and its connexion to the rest of the channel translating equipment is shown in fig. 9. Injection of the signal is made via static relays in the subgroup frequency band with frequencies of 15.825, 19.825 and 23.825 kc/s. Each of these frequencies is obtained from a special signal modulator which modulates the corresponding channel carrier with the frequency 3.825 c/s.

Fig. 9 X 7814

Block schematic for out-band signalling

Units used exclusively with out-band signalling are shown in full outline.

On the receiving side the signals are extracted at the same frequencies. The signalling channel belonging to the same subgroup are amplified in a common amplifier before their final selection by separate signalling receivers. The channel amplifier in the speech path is utilized as amplifier for the signalling receiver.



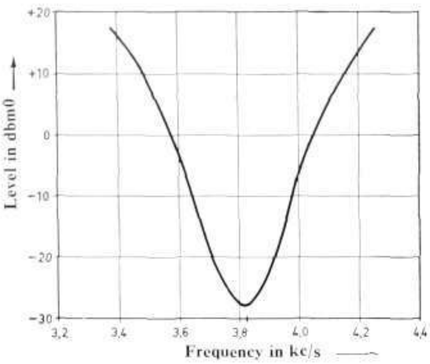


Fig. 10 X 2575

Selectivity curve for low level out-band signalling receiver

The curve shows the level needed to operate the signalling receiver relay, for a signal injected at the group side, receiving.

The signalling channel is protected from interference from the speech channels above and below, partly by the receiver selectivity as shown in fig. 10, and partly by the attenuation on the flanks of the channel band-pass filters. Disturbance by the 84.08 kc/s group reference pilot is prevented by a special suppression filter on the receiving side.

The speech channels are protected from disturbance by the out-band signalling, partly by suppression of the higher sidebands resulting from impulsing by menans of a band-pass filter after the static relay, partly by a suppression filter on the receiving side combined with the channel filter.

In order to determine what requirements need to be set for the suppression of the continuous interfering tone resulting from continuous out-band signalling, listening experiments were carried out at L M Ericsson on a number of test subjects. Actual listening conditions were simulated in an experimental circuit in which continuous interfering tones were switched on while a conversation was in progress. A 3 km subscriber line was included between the source of interference and the telephone instrument. The subjects then gave their impression of the effect of the interference according to a certain scale. The frequencies in question for outband signalling are 3 825 c/s (interference in the speech channel associated with it) and 175 c/s (interference in the neighbouring speech channel). The median results for these frequencies, i.e. for an average listener, are shown expressed in dbm0 in the following table

	175 c/s	3 825 c/s
"Audible, but disturbance insignificant"	−37	−56
"Audible only faintly"	−45	−64
"Inaudible"	−54	−74

These measurements show that the psophometric weighting curve does not give results directly applicable to the interference from continuous tones experienced when using modern telephone instruments.

The levels of interference produced in the channel translating equipment by continuous out-band signalling are: for 175 c/s, below −55 dbm0 corresponding to "inaudible", and for 3 825 c/s, below −65 dbm0 corresponding to "audible only faintly". Since the tests were carried out without noise, and since it is known that noise with a broad spectrum masks high interference frequencies more than low, the results imply that the interference on a connexion with a normal noise level will not be noticeable.

The signalling equipment is designed so as to require a minimum of maintenance. No initial adjustment of the impulsing ratio is necessary: the receiving signalling relay is a polarized relay with mercury-wetted contacts, and has thus practically no wear and needs no adjustment.

The use of the channel amplifier as amplifier for the signalling receiver prevents the occurrence of the dangerous type of fault in which the speech path can be out of order due to a fault in the channel amplifier, while the signalling channel remains operating.

Out-band Signalling, High Level

Signalling is carried out with the same frequency as for low level, *viz.* 3 825 c/s, but at a level of −6 dbm0.

The signalling equipment is identical with that for low level: to change from one signal level to the other some strap connexions are altered, thereby changing the sending level and the gain of the signalling amplifiers.

With high level signalling, the suppression filter for 84.08 kc/s mentioned under low level signalling is not necessary.

In-band Signalling, 1-VF

1-VF in-band signalling is normally carried out with a frequency of 2 400 c/s and a level of –6 dbm0. However, to permit co-operation with other international or national signalling systems, it is possible to provide for the channel translating equipment to use signalling at a frequency other than 2 400 c/s. Suppression of interference frequencies due to unwanted sidebands in the channel translating equipment is such that any signalling frequency between 500 c/s and 3 000 c/s may be used with the maximum level recommended by CCITT.

A block schematic of the signalling equipment together with the channel translating equipment is shown in fig. 11. Signal sending can take place in one of two ways. The figure shows sending using static relays in the same manner as for out-band signalling. An alternative possibility is to inject the signal using normal telephone relays: the injection then takes place ahead of the actual carrier system. When signal sending is effected with static relays as shown in fig. 11, the speech path is blocked during signalling by backing off the diodes of the channel modulator.

The signalling receiver is connected to a special signalling output on the channel amplifier. Since this output is connected in series with the speech output and fed from a very high impedance source, very good decoupling from near-end interference is obtained. By using this principle it is possible both to comply with the CCITT recommendation regarding rejection of near-end interference and also to retain the principle that the signalling passes all the amplifiers in the speech path. The signalling receiver is furthermore designed to comply with all CCITT recommendations for in-band signalling. Here too a polarized mercury-wetted relay is used as signalling relay. No adjustments are needed to hold pulse distortion within permissible limits.

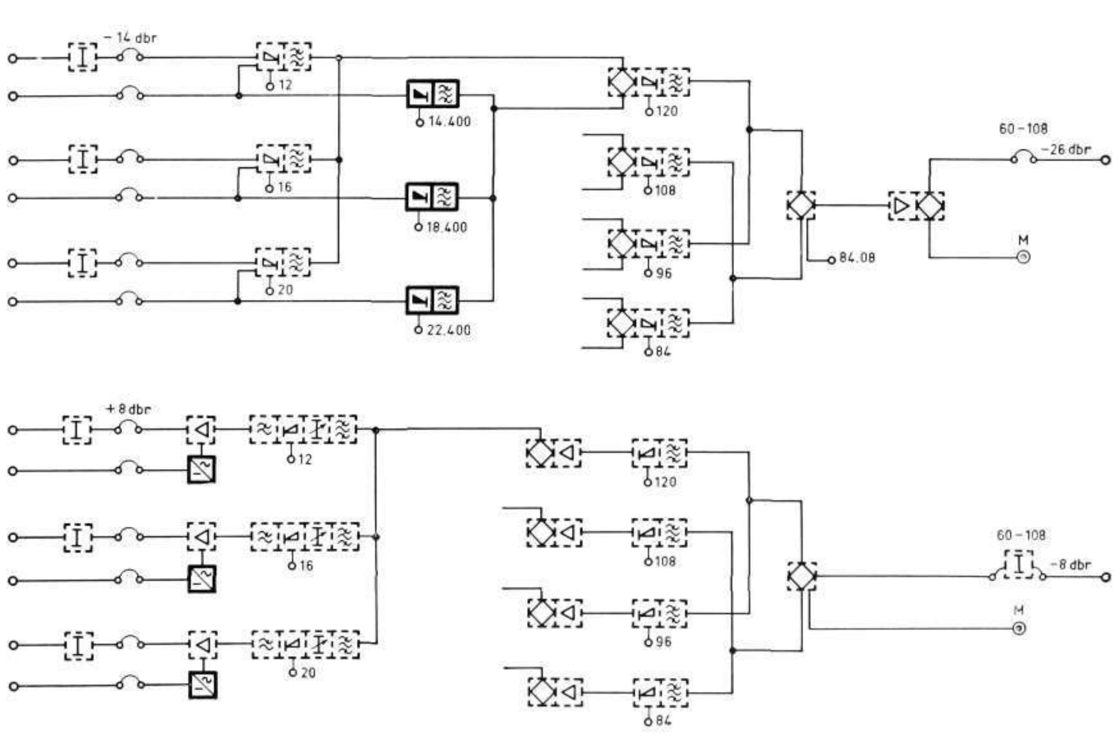
Fig. 11 X 7815

Block schematic for 1-VF in-band signalling

Units used exclusively with in-band signalling are shown in full outline.

In-band Signalling, 2-VF

The signalling equipment is designed for the frequencies 2 040 and 2 400 c/s, the level of each being –9 dbm0, as recommended by CCITT.



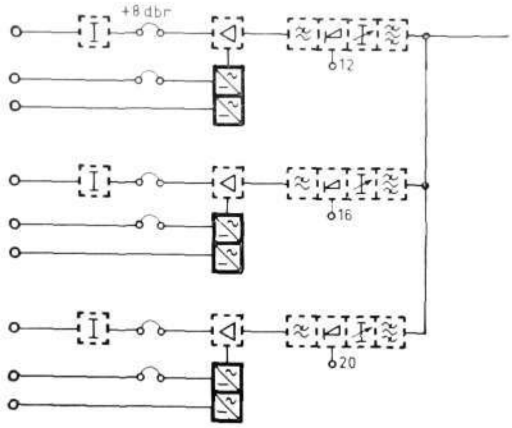


Fig. 12 X 2576

Block schematic for subgroup receiving equipment with 2-VF in-band signalling

The block schematic in fig. 12 shows equipment for 2-VF in-band signalling. Signal sending with this system invariably takes place in the exchange equipment, since it is always a matter of coded signals with a mixture of frequencies. The signalling receivers, one for each frequency, are built on the same principle as the 1-VF receivers except that the second frequency must not affect either the signalling circuit or the guard circuit of the receiver. The method of connexion and properties are the same as described above for the 1-VF receiver.

IV. Technical Data

Frequency ranges:

Nominal bandwidth occupied per channel	4 kc/s
Effectively transmitted speech band	0.3–3.4 kc/s
Nominal band occupied by a group	60–108 kc/s

Nominal levels:

Sending	
VF side	–14 dbr
Group side	–26 dbr
Receiving	
Group side	–8 dbr
VF side	+8 dbr

Nominal impedances

VF side	600 bal.
Group side	75 unbal.

Frequency response

Variation of equivalent relative to 800 c/s, when connected back-to-back on group side, does not exceed	1/3 of CCITT recommendation for international circuit. See fig. 13.

Linearity

For 3.5 db increase in level above nominal test level, the equivalent measured for back-to-back connexion does not increase more than	0.3 db

Fig. 13 X 8263

Variation of equivalent with frequency relative to 800 c/s for individual channels connected back-to-back group frequencies

The limits are 1/3 of the CCITT recommended tolerances for an international circuit. The upper and lower curves show the dispersion for a sample of 60 channels.

Fig. 14 X 8264

Overall variation of equivalent with frequency relative to 800 c/s for all 12 channels of a group, tandem-connected at voice frequencies and connected back-to-back at group frequencies

The limits shown are the CCITT recommended tolerances for a complete international circuit. The flatness of the curve indicates that the systematic error in the individual channel response curves is very small.

Fig. 14

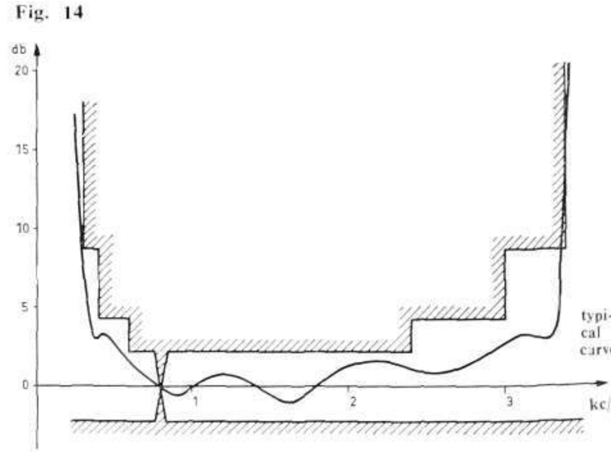


Fig. 13

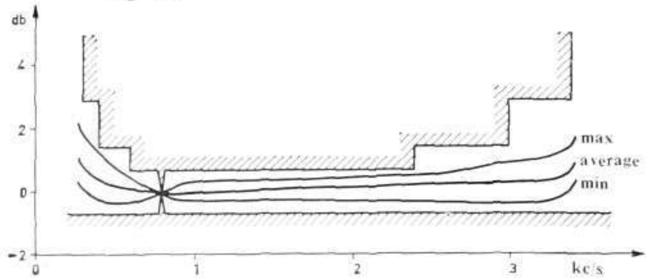
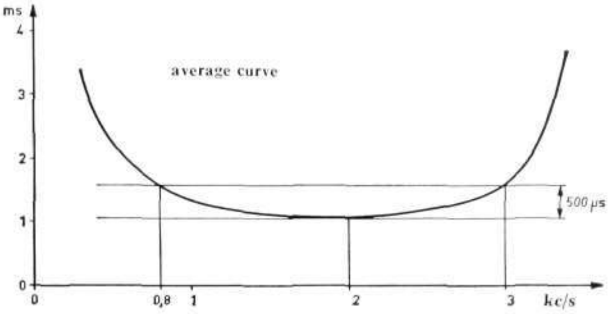


Fig. 15 X 8265

Group delay as a function of frequency for a channel connected back-to-back at group frequencies



Limiting	
For 15 db increase in level above nominal test level at the 4-wire input, the output at the group side does not exceed	+12 dbm0
Carrier leak	
Carrier leaks measured selectively on the group side, sending, in no case exceed	–28 dbm0
Intelligible crosstalk	
For all combinations of near-end and far-end crosstalk, the crosstalk ratio exceeds	75 db
Near-end crosstalk ratio between go and return channels of the same circuit exceeds	50 db
Unintelligible crosstalk	
Crosstalk noise ratio, measured psophometrically, for inverted sideband of adjacent channel fed by a "speech standard"(noise source with same spectral distribution as average speech), better than	67 db
Interference from tones for various types of in-band signalling, such as MFC signalling using two frequencies in the band 500–2 000 c/s with a level of –8 dbm0 each, or 1-VF signalling 2 000–3 000 c/s with a level of –6 dbm0, or 2-VF signalling 2 040/2 400 c/s with a level of –9 dbm0 per frequency, does not exceed	–70 dbm0p
Noise	
Basic noise, measured psophometrically by a back-to-back test in a 0 dbr point with no loading by speech or signalling, less than	50 pW
Noise in loaded system	
Total mean noise in any channel measured psophometrically by a back-to-back test in a 0 dbr point, with all other channels loaded with noise having a speech spectrum to a level of – 6 dbm0 per channel, less than	200 pW

Out-band signalling, low-level

Signalling frequency	3 825 c/s
Signal level	–18 dbm0
Signalling distortion, for impulses or interruptions lasting at least 30 millisec, when the signal level is within ±6 db and the signalling frequency within ±10 c/s of nominal, does not exceed	6 ms

Interference caused by signalling on adjacent channel	
Continuously applied tone, less than	55 dbm0
Interrupted tone, less than	–70 dbm0p
Interference caused by signalling on own channel	
Continuously applied tone, less than	–64 dbm0

Out-band signalling, high level

Signalling frequency	3 825 c/s
Signal level	–6 dbm0
Signalling distortion	as for low level
Interference caused by signalling on adjacent channel	
Continuously applied tone, less than	–68 dbm0p
Interrupted tone, less than	–65 dbm0p
Interference caused by signalling on own channel	
Continuously applied tone, less than	–65 dbm0p

1-VF in-band signalling

Signalling frequency, normally	2 400 c/s
Signal level	–6 dbm0p
Distortion, for impulses or interruptions lasting at least 20 millisec. when the signal level is within ±9 db and the signalling frequency within ±15 c/s of nominal, does not exceed	5 ms
Signal imitations due to speech	
Average number per speech hour of imitations longer than 55 ms, less than	0.1

Near-end interference

The signal receiver is protected from near-end interference so that a signalling frequency, entering from the near end of a circuit lined up for an equivalent of 7 db, has a level at the receiver input at least 60 db lower than the nominal level of the signal from the far end.

Interference caused by signalling in adjacent channel, less than	–70 dbm0p

2-VF in-band signalling

Signalling frequencies	2 040 c/s and 2 400 c/s
Signal level, per frequency	–9 dbm0
Interference caused by signalling in adjacent channel, less than	– 70 dbm0p

Power supply

Voltage	–22 V d.c.
Consumption of a fully equipped group (depending on type of signalling)	15–20 W

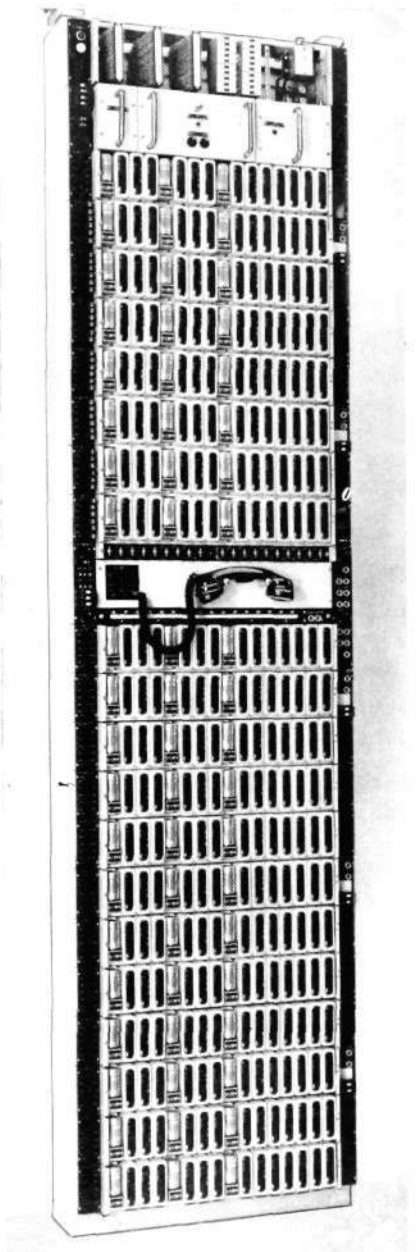


Fig. 16 X 2584

Channel Translating Bay, type ZDG 801

The bay is shown with the front cover plates removed.

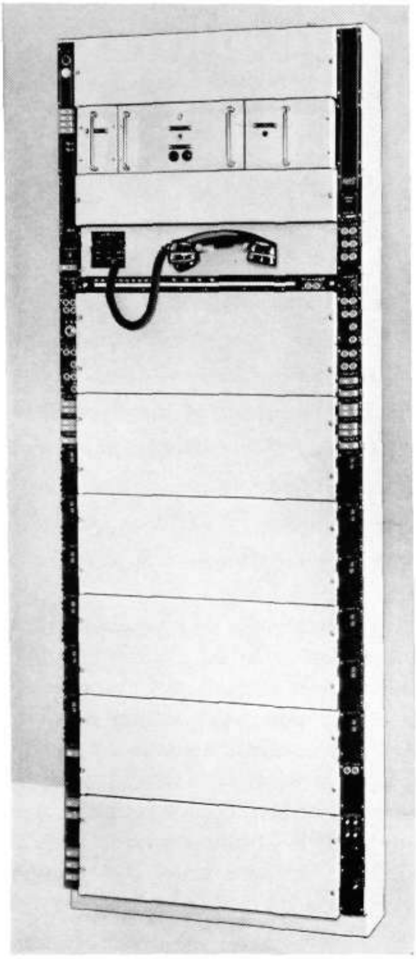


Fig. 17 X 2585

Terminal Bay, type ZCC 801, with multiplex equipment for a 12-circuit radio relay link system

V. Use of the channel translating equipment in various L M Ericsson systems

Descriptions are given below of the Channel Translating Bay, type *ZDG 801*, and the 12-circuit Terminal Bay for radio relay link systems, type *ZCC 801*, as examples of the application of the channel translating equipment in different L M Ericsson carrier telephone systems.

Channel Translating Bay

This bay is used in the terminal equipment for all carrier systems of 60 circuits or more. It is also used for systems with smaller numbers of circuits when multiple equipment for several smaller systems is provided in the same repeater station.

Fig. 16 shows the mechanical layout of the Channel Translating Bay: it contains equipment for five groups. Four-wire extension is provided on the v.f. side. Pads on both the v.f. and group side permit interconnexion with other equipment at various commonly used levels. On the group side interconnexion can also be made to an impedance of 150 ohms balanced as well as the normal 75 ohms unbalanced. The bay is so arranged that without any wiring alteration the choice can be made of equipping it for out-band signalling, high or low level, or 1-VF in-band signalling. To change from one type of signalling to another only requires the exchange of certain plug-in units.

12-circuit Terminal Bay for radio link systems

This bay, providing the carrier multiplex equipment for 12 circuits for use with a radio link, is shown in fig. 17.

In addition to the channel translating equipment, space is provided on the bay for 4-wire terminating sets, compandors, signalling equipment, carrier generating equipment and group modulation equipment to give the band of frequencies sent to the link. For signalling, the choice can made between equipping the bay for out-band signalling, high or low level, or 1-VF in-band signalling.

VHF 5-kilowatt FM Broadcast Transmitter Type 21-KK-5

L. BUCHHOLZ, A/S ELEKTRISK BUREAU, OSLO

UDC 621.396.61
621.3.029.62
LME 8512, 8042, 85102

The broadcast transmitter described in this article has been developed and produced by A/S Elektrisk Bureau of Oslo. The transmitter works on a centre frequency in the 87.5–100 Mc/s band. Three transmitters of this type have been put into service so far, at Kirkenes, Tana and Hammerfest in the north of Norway. A large number of others have been delivered or are under production. A 10-kilowatt type is under development, one of which is to be installed in the new combined TV and FM tower on Tryvannshöyden near Oslo.

Owing to the Norwegian topography a very large number of broadcast transmitters will be required if good quality reception is to be available to the entire population. A nationwide plan will be extremely expensive, and each individual transmitter, therefore, must obviously cover the largest possible area. As a rule the transmitters are installed in unattended stations on mountain tops which are difficult of access, especially in wintertime when they may be cut off for several weeks from any possibility of inspection or repair. The transmitters often have to be supplied from small local power plants, so that large voltage fluctuations must be considered. For these reasons great emphasis has been placed on maximum reliability and on facilities for automatic switching-in of standby equipment without necessitating duplication of the entire transmitter.

Technical Data

There are no international agreements concerning quality or operational requirements for FM broadcast transmitters. The U.S.A. and W. Germany, however, have established standards for their respective countries. *The Norwegian Telecommunications Administration*–which is responsible for the transmitters used by the *Norwegian Broadcasting Corporation*–follows the German specifications, which are best suited for the conditions in Europe, among other reasons because the European manufacturers of FM receivers observe the European standards for frequency range, pre-emphasis etc. The German specifications are contained in *Pflichtenheft betr. UKW-FM-Rundfunksender*, issued by *Arbeitsgemeinschaft der Rundfunkanstalten der Bundesrepublik Deutschland*. The transmitter complies with these requirements, as also with special requirements of the Norwegian Telecommunications Administration, and has the following data:

Frequency swing at 100 % nominal modulation	75 kc/s
AF input level for 100 % modulation at 1000 c/s	$<$ 6 dbm
Input impedance, program line, balanced	600 ohms
Pre-emphasis	50 ± 5 μsek
Distortion at 100 % modulation 40–15 000 c/s	$<$ 1 %
Response without pre-emphasis, 40–15 000 c/s with reference to 1 000 c/s	$< \pm 1$ db
FM noise level with reference to 100 % modulation	< -60 db
AM noise level with reference to 100 % AM	< -45 db
Synchronous AM (incl. AM noise) at 100 % FM and with reference to 100 % AM	< -40 db
Radiated power, normal operation	5 kW

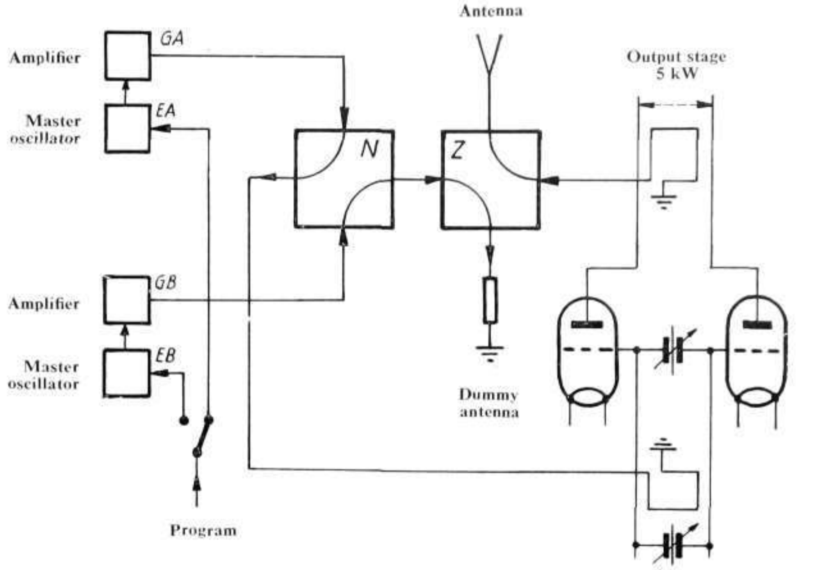


Fig. 1 X 8280

Automatic standby facilities

Radiated power, standby in event of fall-out of output stage	600 W
Feeder-terminal impedance	60 ohms
Frequency range, continuous	87.5—100 Mc/s
Frequency drift	$< \pm$ 1 000 c/s
Accuracy of frequency setting	$< \pm$ 200 c/s
Centre-frequency stability at 100 % modulation	$< \pm$ 2 000 c/s
Crystal frequency, fraction of antenna frequency	1/5 400
Radiated harmonic power	$<$ 25 mW

Automatic Standby Facilities

In addition to the usual safety arrangements for protection against damage, the attempt has been made to respond to the aforementioned reliability requirements by means of standby equipment which is automatically switched into operation. This equipment is shown in fig. 1. As will be seen, the master oscillator and the amplifier (with a max. power of 600 watts) are duplicated so as to provide two sets of independent driver units *EA-GA* and *EB-GB*. The coaxial output terminals of these units are connected to a motor-controlled coaxial selector »*N*». Normally the output stage of the transmitter is excited by *EA-GA* via selector »*N*», while *EB-GB* acts as standby. Via another motor-controlled coaxial selector »*Z*» the standby unit is connected to the dummy antenna; and tests can be performed on the standby unit while the other part of the transmitter is in operation on the normal antenna. Both master oscillators–which also comprise AF amplifier and modulator–are in operation all round the clock because of the frequency control device. The last stage alone is cut-off by means of a highly negative grid bias as long as the respective master oscillator is not in use.

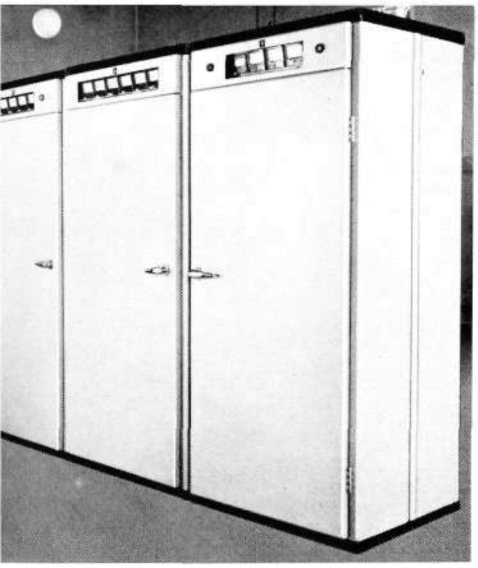


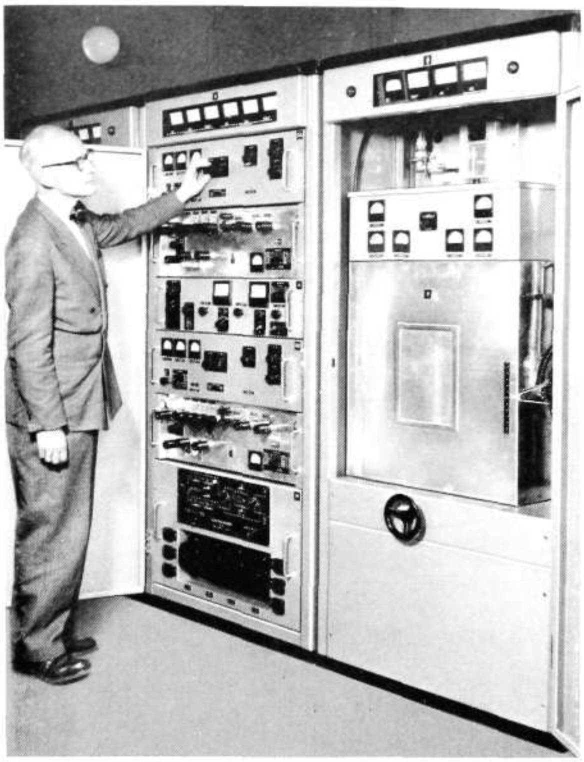
Fig. 2 X 2583

The transmitter consists of three bays

Centre: A for drivers
Left: C for rectifiers
Right: B for output stage

In the event of failure in the driver units *EA-GA*, a relay in *GA* indicates the absence of output power; the voltages to *GA* are automatically disconnected, while the voltages to *GB* are switched on and coaxial selector »*N*» is turned through 90° so that the output stage is now driven by *EB-GB*.

In the case of a permanent breakdown in the output stage the voltages are automatically cut off from the latter and coaxial selector »*Z*» is turned 90° so that one of the amplifiers is connected directly to the antenna. This amplifier is at the same time supplied with double anode voltage–since only a reduced power is needed for excitation of the output stage–and delivers to the antenna 600 watts which thus constitutes the standby power of the transmitter.



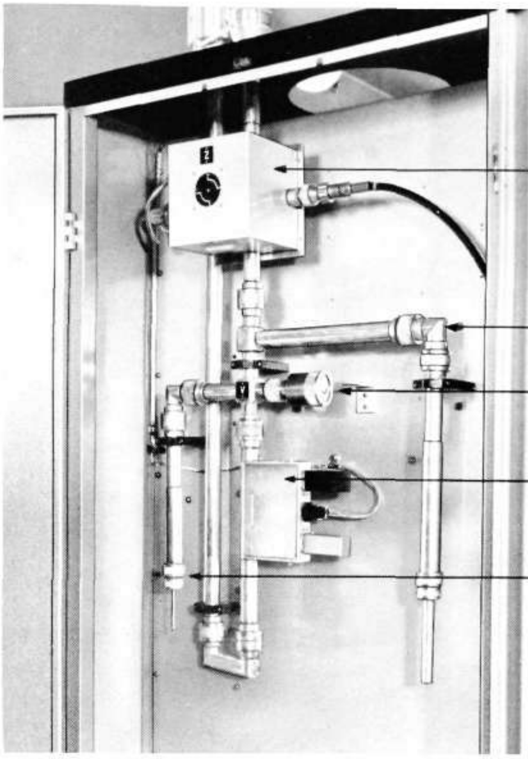


Fig. 3 X 8271

Drivers etc. and output stage

In the bay on the right are seen (from top) grid circuit, coupling loop and anode tuning knob

Fig. 4 X 8272

Output stage, rear view

Mechanical Construction

As will be seen from fig. 2, the transmitter consists of three bays formed as mechanically separate units for ease of transport. Bay *B* (right) contains the output stage, which is also shown in figs. 3 and 4.

Bay *C* (on the left in fig. 2) is shown separately in fig. 5. The relay panel in fig. 5 registers faults in the output stage and decides what automatic action shall be taken in each particular case.

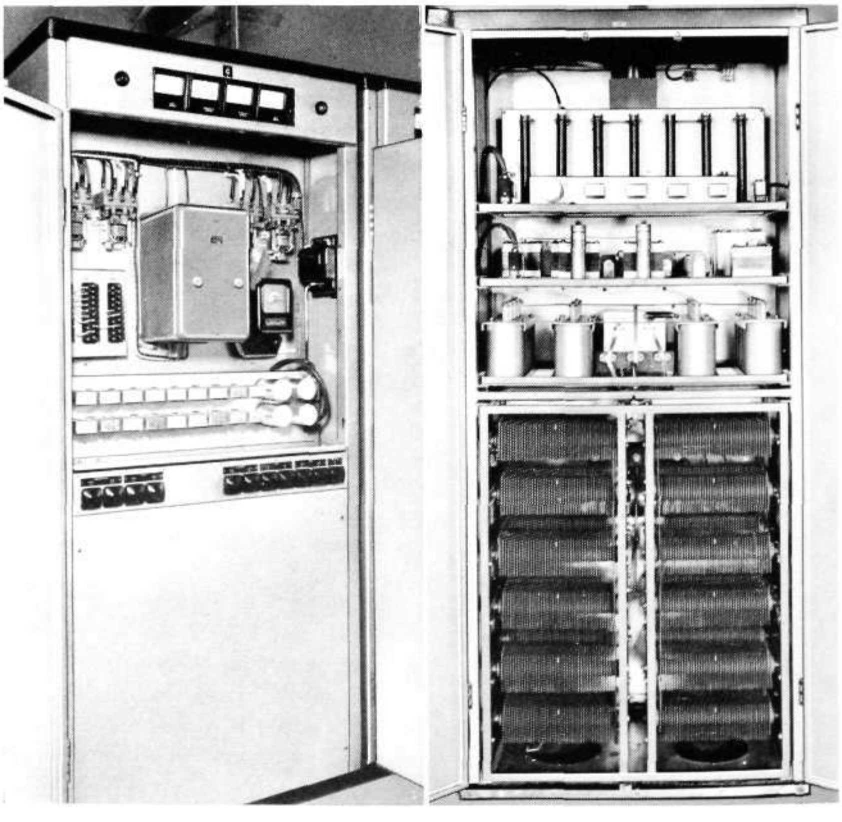


Fig. 5 X 7816

Power bay

Left: front view. From top: main switch, relay panel and fuses.

Right: rear view. From top: bleeders, grid-rectifiers, 5 kV rectifier filter and 5 kV rectifier elements.

Fig. 6 X 7817

Driver bay

Left (front view), from top: amplifier GA, master oscillator EA, instrument panel, amplifier GB, master oscillator EB and power distribution panel.

Right (rear view), from top: rectifiers for amplifier and master oscillator, instrument panel, rectifier for amplifier and master oscillator, coaxial selector «N» and power distribution panel.

The centre bay *A* is shown separately in fig. 6. The bay contains six draw-out panels running on roller slides. The bottom panel, the distribution panel for the amplifiers, is shown separately in fig. 7. The operation board provides a clear survey for manual operation of the transmitter. It has engraved blocks for drivers and output stage and has manual knobs for setting the program input and the two coaxial selectors, the arch lines showing the path of the program channel and the radio frequency circuitry through the coaxial

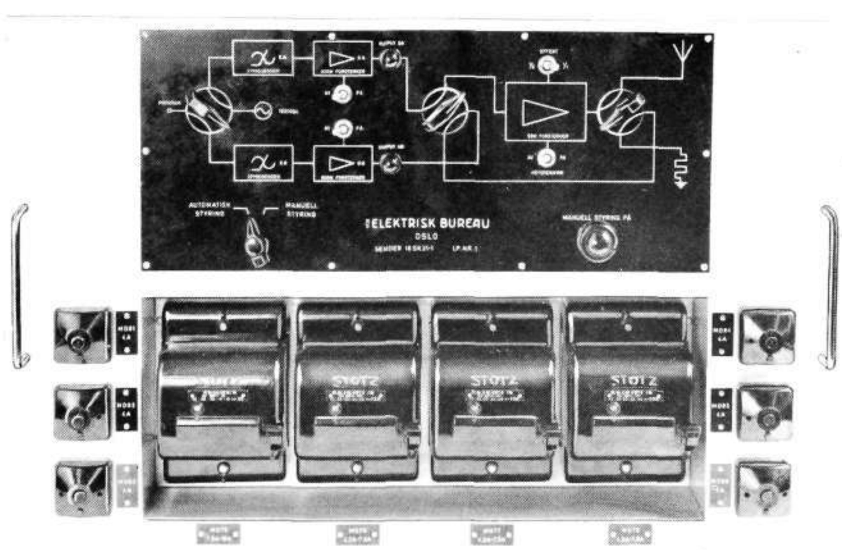


Fig. 7 X 8273

Power distribution panel for amplifiers

Top: operation board

selectors. There are also switches for HT to amplifiers and output stage, and a selector for automatic and manual operation. When this selector is set for automatic operation, closing of a 24 V d. c. starting terminal set via an external lead initiates the starting operations which proceed in the correct sequence under the control of time relays for the required delays and irrespective of the settings of the other switches and selectors on the operation board.

Safety Devices—Automatic Operation and Storage of Fault Indications

All units of the transmitter are equipped with conventional safety devices such as fuses, thermostats, air current relays, voltage and overload relays, etc.

In addition there is a relay panel for the output stage, containing 16 relays which, apart from controlling the automatic start and stop operations, respond to altogether 12 sources of fault indication. In the case of such faults occurring, these relays either disconnect the output stage and send an order to feed 600 watts from one of the driver stages directly to the antenna or, for certain kinds of transitory fault, after switching off the HT voltages, make a tentative reconnection, first at full power and thereafter at about $^1/_3$ power. Switching to $^1/_3$ power is done by changing from delta to star connection on the primary side of the rectifier transformers. The number of attempts to switch to $^1/_1$ and $^1/_3$ power can be adjusted within certain limits. At the end of the preset number of attempts, the output stage is rendered completely dead, the heater voltage and cooling fan being also switched off, and the driver is connected directly to the antenna with an output power of 600 watts.

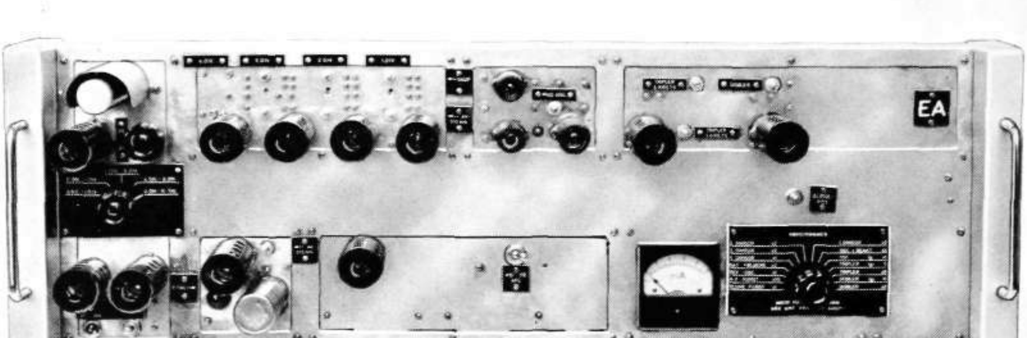
In connection with the 12 fault indication facilities there is a relay-controlled lamp panel which, on the occurrence of any of these faults, lights a red lamp with text indicating the source of the fault. The lamp remains lit even when the transmitter is stopped at the end of a program period; whenever the superviser visits the station, therefore, he can see that a fault has been indicated and its source. Accordingly it should always be relatively simple to trace a fault.

Power Supply—Rectifiers

The transmitter is driven from a 230-volt, 50-cycle 3-phase system, its power consumption being about 14 kVA. Metal rectifiers are used in all power units. No mercury vapour tubes are employed, so that all faults caused by backfiring of such tubes are eliminated. All smoothing capacitors are of the self-healing metallized paper type. To ensure full reliability all components are amply dimensioned.

Fig. 8
Master oscillator

X 7818



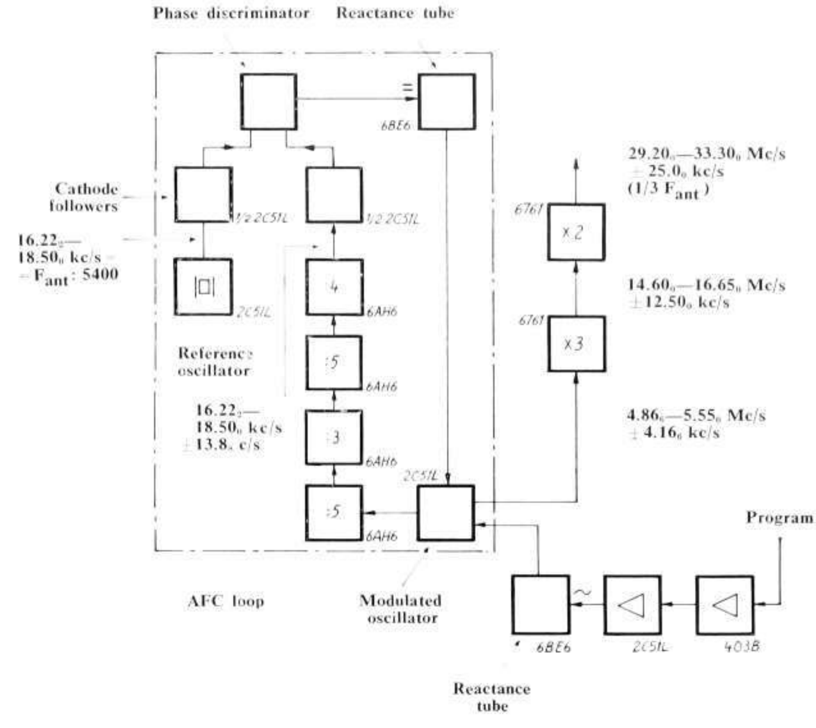


Fig. 9 X 8281

Block schematic of master oscillator

Frequency swing values are given for 100 % modulation

Master Oscillator

Apart from the frequency-modulated oscillator, the *master oscillator unit* comprises a two-stage frequency multiplier (trebler and doubler), automatic frequency control (AFC), a two-stage program amplifier, and a cathode ray tube for easy trimming and quick test of the AFC circuits. The master oscillator (fig. 8) is mounted on its rectifier unit with which it forms a draw-out panel. In relation to the rectifier the master oscillator can be swung down so as to be readily accessible for servicing. A block schematic of the master oscillator is shown in fig. 9.

In the amplifier excited by the master oscillator there is a trebler stage. And since the master oscillator contains a trebler and a doubler, the frequency-modulated oscillator operates at a frequency of $^1/_{18}$ of the antenna frequency. The frequency swing of the oscillator is also $^1/_{18}$ of the frequency swing in the antenna. To the oscillator's anode tank circuit are connected two reactance tubes, both capacitive, with different functions. One provides the frequency modulation by means of a voltage applied from the two-stage program amplifier, while the other forms part of the AFC loop. The latter consists of a comparing unit, a phase discriminator, which compares a quotient of the oscillator frequency (the frequency divided by 300) with the frequency of a crystal-controlled reference oscillator. The phase discriminator is a very reliable device for detection of even a very small difference of phase between two oscillations of adjacent frequencies. But since one of the two frequencies to be compared is frequency-modulated, arrangements must be made to ensure that the modulation index to which the phase discriminator is exposed is less than the maximum modulation index at which it can operate without losing its discriminating ability, that is, its ability to supply on its output terminals a signal (varying d. c. voltage) depending upon the instantaneous phase difference.–It should be noted that the supplied signal must not follow the modulation but only comparatively slow changes of the centre frequency, and this is achieved by suitable filtering of the signal.–The maximum permissible modulation index can in practice be put at about 1 radian. At the lowest anticipated modulation frequency, $f = 40$ c/s, the modulation index of the modulated oscillator is given by

$$\beta = \frac{\Delta F}{f} = \frac{75 \text{ kc/s}/18}{40} = \text{about } 104 \text{ radians}$$

To reduce this index to a value below 1 radian, the oscillator frequency –and so the frequency swing as well–is divided by 300 in a four-stage divider ($5 \times 3 \times 5 \times 4 = 300$), so that the modulation index with which the phase discriminator operates will be $104 : 300 = 0.347$ radian.

The divider stages are all self-oscillating block oscillators which are synchronized by a voltage from the preceding stage, this voltage being in harmonic relationship to the fundamental frequency of the associated divider. All components in each individual divider are dimensioned for optimal synchronization width. In this way a range of from $\pm$ 2.5 till 5 per cent variation of the L-value of each divider tank circuit has been achieved without loss of synchronization. These wide synchronizing ranges make trimming of the divider chain very simple without the need for special instruments, and there is no likelihood of the dividers falling out of synchronization.

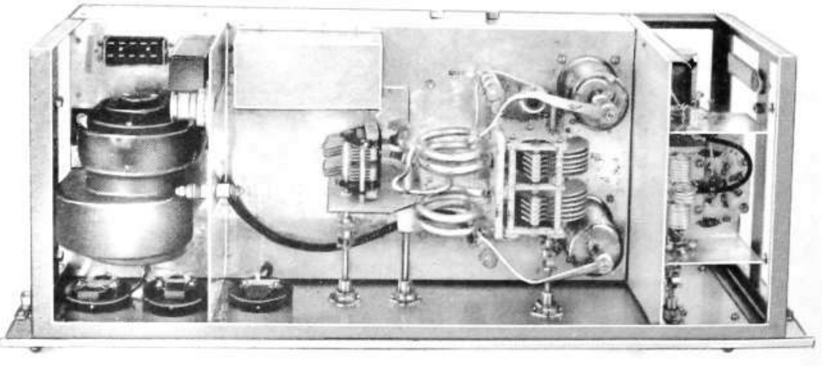
The oscillator frequency divided by 300, which lies in the range of 16.22–18.5 kc/s, and the equal frequency from the crystal oscillator are applied to the phase discriminator through their respective cathode follower circuits. In the event of phase drift of the divided frequency from the modulated oscillator in one direction or the other in relation to the reference frequency, the phase discriminator responds by supplying at its output terminals a varying positive or negative d. c. voltage of about max. 1.5 V which is applied to a grid of the reactance tube, which accordingly automatically corrects the frequency of the oscillator.

For quick trimming of the oscillators and the divider chain there is a small cathode ray tube, permanently mounted in the master oscillator, the tube being connected to a selector switch which has four positions for indication of the Lissajous figures corresponding to the frequency divisions and which can also compare the divided oscillator frequency with the reference frequency. In that position of the selector, which indicates the latter two frequencies (reference oscillator and fourth divider), the cathode ray tube should show a stationary ellipse when the frequency is under control. It is thus very simple to check at any time that the frequency control is working, merely by switching on the cathode ray tube.

The master oscillator is equipped with a common instrument with a selector switch for measurement of all tube currents.

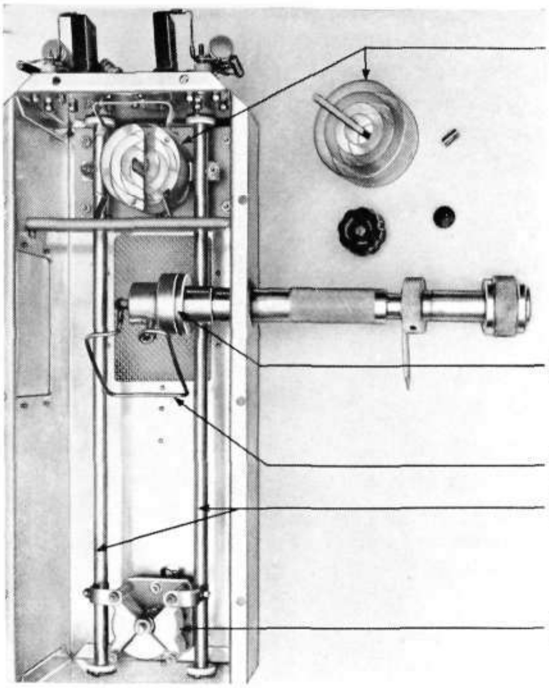
600-Watt Amplifier

The amplifier, which is shown uncovered in fig. 10, includes a trebler stage, double tetrode *QQE 06/40* which excites the final stage of the amplifier with the full antenna frequency. The final stage of the amplifier has two tetrodes *QB 3/300* in push-pull connection and, like all previous stages of



X 8274

Fig. 10
600-watt amplifier



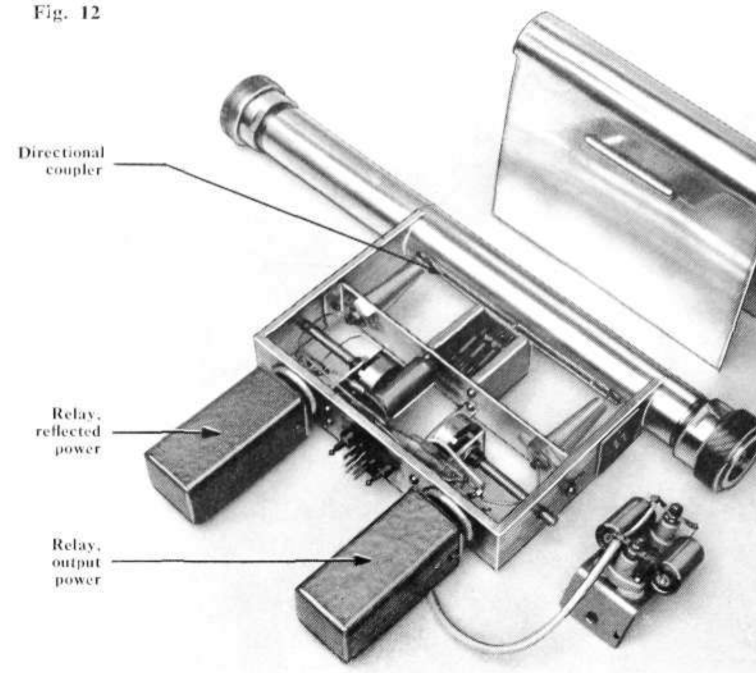


Fig. 11 X 8275

The distributed grid circuit (Grid-matching transmission line)

Close-up

Fig. 12 X 8276

Reflectometer

Close-up

the transmitter, works with lumped circuits. There is no anode-grid neutralization, but the inductances of the screen grid leads in tubes *QB 3/300* are series-tuned by a »ganged» double capacitor. The amplifier is equipped with a separate instrument for reading the cathode currents of the final stage, whereas all other tube currents can be read on a common instrument provided with a selector switch. Another individual instrument, in association with a directional coupler and a two-throw switch, is provided for reading the power output and any reflected power due to mismatch. A diode circuit with a relay indicates whether the radio frequency power of the amplifier is present.

Output Stage

The output stage of the transmitter (shown in figs. 3 and 4) works with Lecher lines on the grid side and on the anode side and has two tetrodes *QB 5/3 500* in push-pull connection. Tuning on the grid side is performed by a series capacitor in the feeder circuit and a split-stator capacitor across the Lecher line. Part of the grid transmitter line with coupling loop and capacitors is shown in fig. 11. The balancing capacitor serves to equalize the exciting voltages and anode currents of the two tubes. On the anode side tuning is performed by means of a shorting bridge across the Lecher line. The bridge is operated with a knob via gearing. A series-tuned coupling loop applies the anode output (5 kW) to a 60-ohm feeder via the aforementioned coaxial selector »*Z*» shown in fig. 4. To ensure compliance with the strict requirements in respect of harmonic radiation, max. 25 mW, the following coaxial line filters are provided:

I. Even harmonics:	$\lambda/4$ closed line,	30 ohms
II. 3rd harmonic:	$\lambda/6$ closed line,	120 ohms
III. 5th harmonic:	$\lambda/20$ open line,	68 ohms

Filter I in itself constitutes a parallel circuit to, and consequently does not affect, the fundamental frequency, while filters II and III in combination, by matching of their characteristic impedances, also form a parallel circuit to the fundamental frequency. The tuning conditions for the fundamental frequency are therefore not influenced by the filter lines. In fig. 4 is also seen a reflectometer, a close-up of which is shown in fig. 12. This consists of a

Fig. 13 X 8277

Instrument panel

Distortion meter (left) and deviation meter (right)

directional coupler with two signal relays for output power and reflected power. To the directional coupler are also connected two instruments, mounted on top of bay B, for reading the output power and reflected power. The output stage is connected to antenna and dummy antenna via external feeder cables equipped with Dezifix plugs type D.

The tubes are forced-air cooled, and the presence of the air current is indicated and ensured by an air pressure relay on the supply side. The tubes, like all other tubes of the transmitter, are a. c. heated.

Instrument Panel

The instrument panel of the transmitter is shown in fig. 13. This panel permits continuous testing of frequency swing (deviation) during operation of the transmitter, as well as testing of distortion through the transmitter on application of 1 000 c/s either from an external AF generator or from a built-in test oscillator with harmonic distortion below 0.1 %. The radio frequency is applied to the panel from a probe in the output stage of the transmitter through a coaxial cable. The radio frequency, in the range of 87.5–100 Mc/s, is mixed with a crystal frequency to an intermediate frequency of 150 kc/s (± 75 kc/s swing) which is amplified in a three-stage limiter-amplifier. The AF component is extracted after differentiation of the clipped signal and is applied to an AF amplifier through a low-pass filter with cut-off frequency slightly above 15 000 c/s which suffices to allow harmonic components of a 1 000 c/s signal to pass. After the AF amplifier the signal is applied to a deviation metering set, consisting of an amplifier triode in connection with a diode instrument, and also to the distortion metering set. The latter comprises a high-pass filter with cut-off frequency about 1 500 c/s, so that harmonics of 1 000 c/s may pass to the distortion amplifier which consists of two triode sections associated with a diode instrument for reading the reference level and distortion values.

The CR Unit—a Rational Contact Protection Component

I BORGSTRÖM, TELEFONAKTIEBOLAGET LM ERICSSON, & O STERNBECK, AB RIFA, STOCKHOLM

UDC 621.319.4
621.3.015.54:621.3.064.46
LME 1063, 8335, 7319, 7339

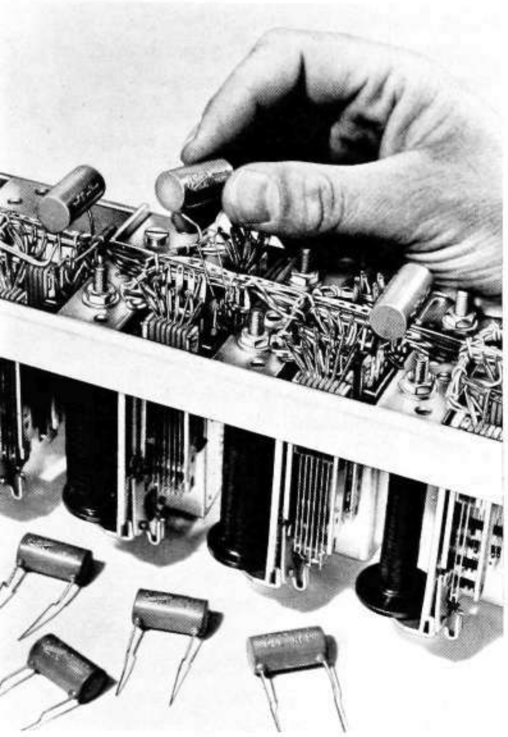


Fig. 1 X 2578
CR units on relay set

Recent developments in automatic switching technique have been followed by increased demands on the life of relay contacts. Largely for this reason AB Rifa in cooperation with the Telephone Exchange Division Laboratory of L M Ericsson has developed a new contact protector, the CR unit described in this article.

When an inductive circuit is opened, a spark is formed in which material is removed from the contacts in liquid or gaseous state. Even if the loss of material due to a single opening is extremely small, the contacts will be destroyed by erosion long before the several hundreds of millions of operations often demanded of them, unless efficient "spark quenching" arrangements are provided. The principle of spark quenching is that the inductive current is diverted from the contacts and successively reduced, at the same time limiting the breaking voltage between the contacts.

The contact protection circuit is usually connected as a shunt to the inductance as shown in fig. 2, but sometimes be placed across the contacts. There are three basic types of contact protectors; carbon resistors, voltage-dependent resistors, and RC circuits. In the choice of contact protection a number of factors must be taken into account, such as the required contact life, breaking current, operating voltage, breaking voltage, release lag of relay, the space available for the contact protection circuit, and its cost.

The most effective contact protection, which gives the longest contact life, is a capacitor in series with a resistor. On opening of the contact the capacitance takes up the energy stored in the magnetic field of the inductance, and the resistance limits the charging or discharging current when the contacts close again. Apart from their good contact protecting action, RC circuits have the advantage that their power consumption is entirely negligible.

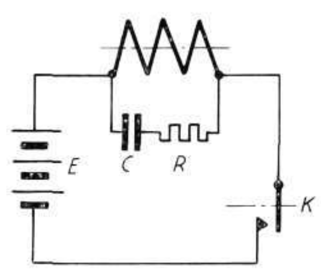


Fig. 2 X 2591
Inductive circuit with RC shunt

E battery — R resistor
C capacitor — K contact

A capacitor-resistor combination, however, is a comparatively expensive and bulky form of contact protection. Another form of protector has therefore been developed in which these two components are combined in a single unit (BTL protection networks). In order further to simplify the capacitive contact protection, AB Rifa made trials with bipolar electrolytic capacitors in which the series resistance consisted of a resistive electrolyte. The contact protection was satifactory, but the properties of the components were too unstable. Trials were instead made with metallized paper capacitors of special design, which resulted in the CR unit.

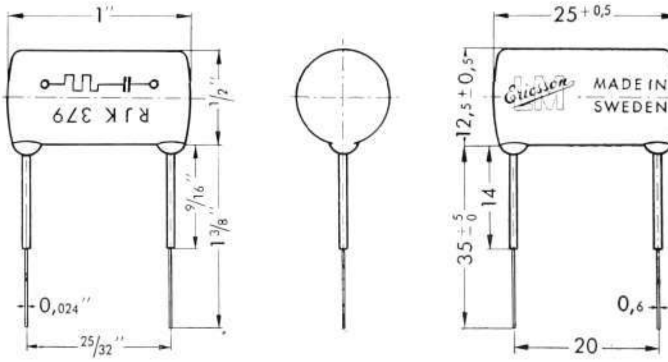


Fig. 3 X 8266
Dimensions of CR unit

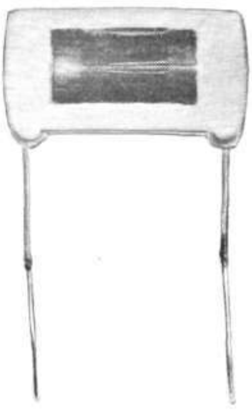


Fig. 4 X 2580

Cross-section of CR unit

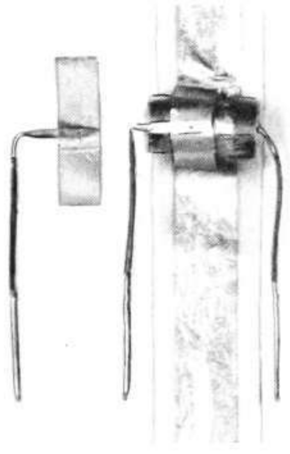


Fig. 5 X 2581

Partially unwound roll and lug

The Rifa CR unit is in principle a metallized paper capacitor in which the resistance in the thin metallized electrodes serves as series resistance to the capacitance. By special location of the terminations in the capacitor winding the magnitude of the series resistance has been made comparatively independent of the frequency (fig. 6). For effective contact protection the series resistance must be sufficiently high during the entire discharging period, so as to avoid too high a current on closure of the contacts.

The winding of the CR unit is of the same size as that of a metallized paper capacitor with the same data. It is impregnated with a high melting point wax and is moulded in a polyester compound with very good moisture-resistant properties. The CR unit meets with a good margin to spare the IEC specifications for humidity class V, *i.e.* 21 days' exposure to 90–95 % humidity at 40°C, which is considered sufficient for this type of component in indoor use. For extremely troublesome climatic conditions a special type is made which meets the requirements of IEC's highest class IV.

Rifa's CR unit is neither larger nor heavier than a corresponding MP capacitor and, owing to its simple design, lends itself to mass production. Furthermore it is relatively insensitive to over-voltage, and in practice the self-healing properties of the metallized paper preclude any risk of short circuiting. On the other hand the maximum permissible instantaneous current is limited to 300 mA.

The voltage process across the contact on breaking of an inductive circuit with different forms of contact protection is shown in fig. 7. The breaking voltage, which affects the contact wear, should be low. It is determined by the product of the resistance of the contact protector and of the breaking current forced through the contact protector by the inductive voltage. If the contact protector is an ordinary resistor, its resistance must not be especially low, otherwise the shunt will consume a considerable power and will greatly prolong the release lag of the relay. The comparatively high resistance means that the breaking voltage (U_{b1} in fig. 7) will be high and consequently that the life of the contact will be fairly short. A considerable improvement is obtained with a voltage-dependent resistor, which has a high resistance and therefore small current consumption at the battery voltage, but very much lower resistance during the time when the breaking current is passing through the resistor. The breaking voltage (U_{b2}) will therefore be moderate.

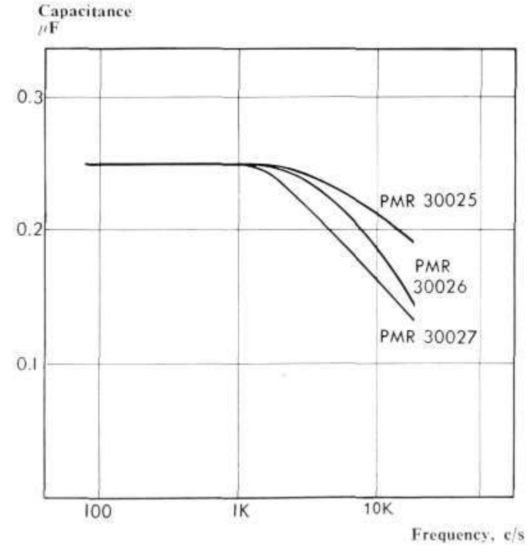
The lowest breaking voltage (U_{b3}) and the longest contact life are provided by an RC circuit in which the resistance can be chosen solely in consideration of the contact protection effect, since the capacitor blocks the passage of the direct current. After the actual break, which takes place very rapidly, the voltage between the contacts rises further, since the capacitor is charged by the

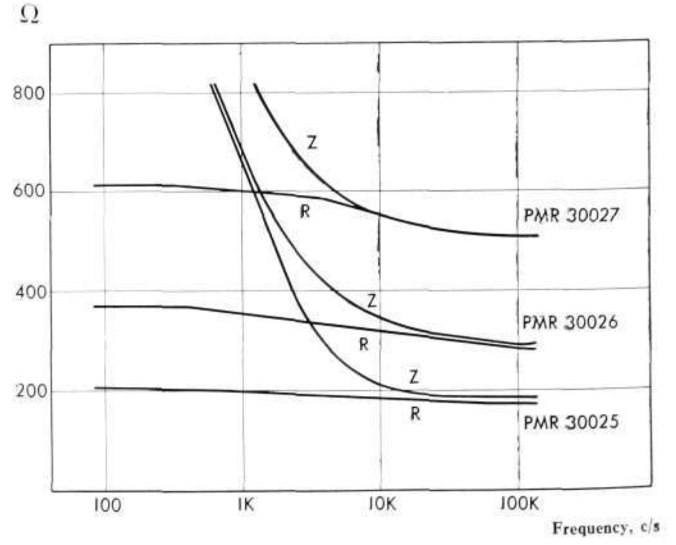
Fig. 6 X 2582 X 8267

Frequency response

R resistance

Z impedance





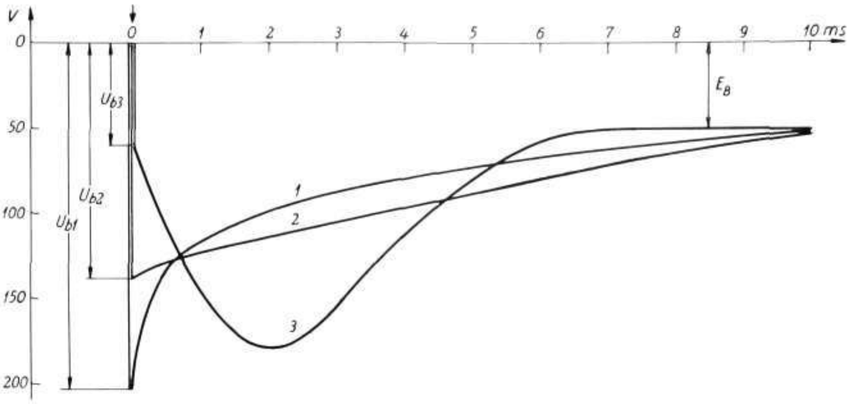


Fig. 7 X 8268

Typical voltage processes across contacts on opening of an inductive circuit based on cracked carbon resistor (curve 1), voltage-dependent resistor (curve 2), and CR unit (curve 3) for contact protection

E_B battery voltage
U_{b1}—U_{b3} breaking voltages

inductive current. The magnitude of this subsequent rise in voltage has no significance for the wear of the contacts, whereas the rate of rise of the voltage must be kept within certain limits. The capacitance in a contact protection circuit, measured in microfarads, should as a rule not be below the amperage of the breaking current. Otherwise the capacitor voltage may rise so quickly as to cause a risk of discharges between the contacts while they are still close together after opening. Moreover, the peak voltage across the capacitor would be so high that special attention would have to be paid to voltage conditions when deciding on the choice of capacitor.

Contact life tests and other studies show that a CR unit is comparable with an ordinary RC circuit consisting of capacitor and series resistor. The specifications of the CR unit have been chosen to suit the most common loads and life requirements for relay contacts. It can be used at battery voltages from 24 to 60 V for breaking currents up to 300 mA, at which it gives silver-copper-contacts a life of 50 to 1 000 million operations depending on the loading conditions. The contact life has been determined empirically so that a definite relation could be established between the resistance in the relay circuit and in the contact protection circuit in order to attain the best contaction protection effect. But since the dependence of contact life on resistance is not especially critical, the number of types of CR unit could be limited to three.

Apart from the good contact protection afforded by the CR unit, it should be pointed out that its current consumption is entirely negligible and that it does not prolong the release lag of relays. In these respects as well the CR unit

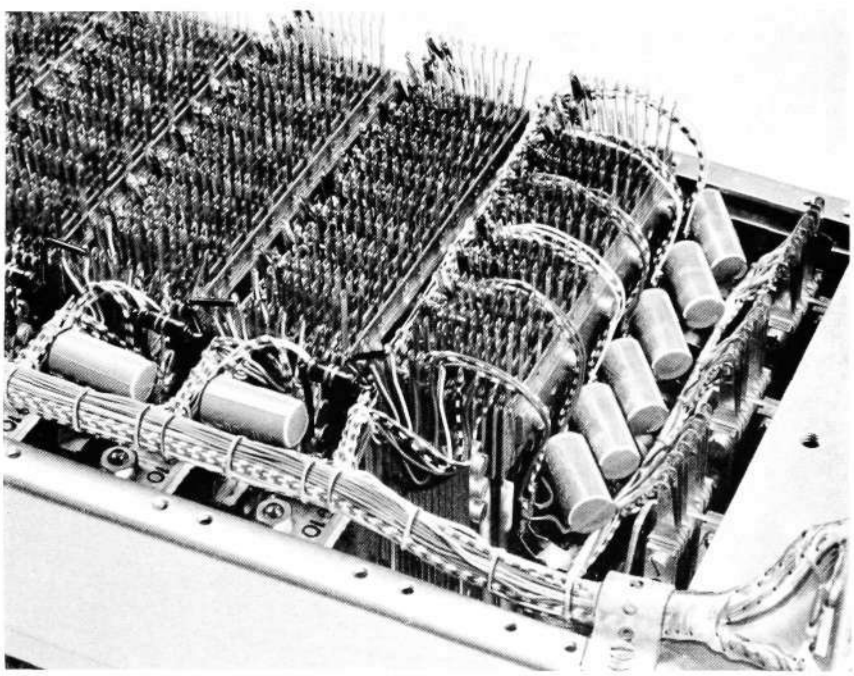


Fig. 8 X 8269

Crossbar switch with CR units

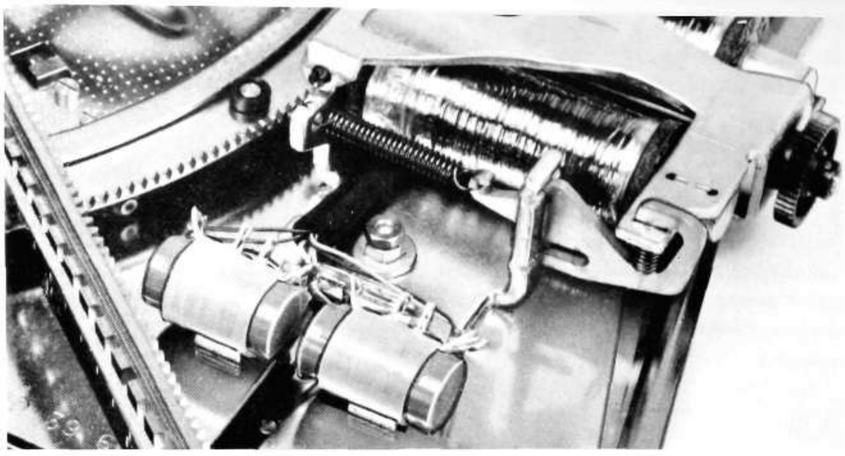


Fig. 9 X 8270

CR units on 500-point switch

is superior to resistive shunts. The current cost, which essentially is the cost of the power equipment, is of the order of one to one and a half dollars per W, an important point in large plants with tens of thousands of contact protection shunts.

Since the CR unit is usually connected in parallel with the circuit inductance, the natural procedure is to solder the contact protection device direct to the relay tags as shown in fig. 1. The wire terminations, which also support the CR-units, are bent to a suitable shape and cut with a special tool prior to assembly. On crossbar switches and multicoil relays as well, the CR units are soldered to the tags (see fig. 8). On 500-point switches, on the other hand, they are fitted in plastic holders which at the same time provide a point of attachment for the tags as shown in fig. 9.

Mass production of the CR units, made mandatory by a persistently and rapidly rising demand, has been achieved by very close control over materials and processes. Quality is checked by a combination of terminal inspection of every unit produced and detailed investigation of samples from each batch. This latter includes a loading test consisting of 300 million charges and discharges at 280 V with 300 mA pulsing current. Since the CR units pass this test very well, they will certainly have as long a life as the contacts they are to protect.

Ericsson LM NEWS *from All Quarters of the World*

Europe's Largest C.T.C. Plant to be Equipped by L M Ericsson

The office of what will be the largest C.T.C. system in Europe was opened by the Swedish State Railways on January 30 this year. The C.T.C. office is at Ånge, from which four stations on the Ånge–Bräcke line have been controlled since 1955.

In conjunction with the opening of the new Ånge office, a section comprising 135 km of line with 16 stations was taken into service. By about September 1 it will be extended to include another 7 stations, making 23 stations and 173 km of line. On completion of the Långsele–Mellansel section by the end of the year, a further 10 stations and 91 km of line will be under C.T.C. operation. During 1962 an extension will be made down to Ljusdal, comprising 99 km with 13 stations. The entire C.T.C. line will then cover 358 km with 43 stations.

The plant is keyset-operated and the control desk is so arranged that a single person can control the entire plant during low traffic periods. During high traffic periods the plant is operated by two persons with one keyset each. The office has two train-graphs.

From inauguration of C.T.C. system at Ånge — largest in Europe. (From left) Chief Superintendent S. Persson, Chief Engineer G. Knall, Signal Engineer H. Brockman, Signal Inspector F. Lindsjö, District Manager H. Palm, all of the Swedish Railways; H. Insulander, Man. Dir. of L M Ericssons Signalaktiebolag; and Å. Karsberg, Director Engineering, S. Lundgren, Chief Signal Engineer, and N. G. Eriksson, Traffic Superintendent, of the Swedish Railways.

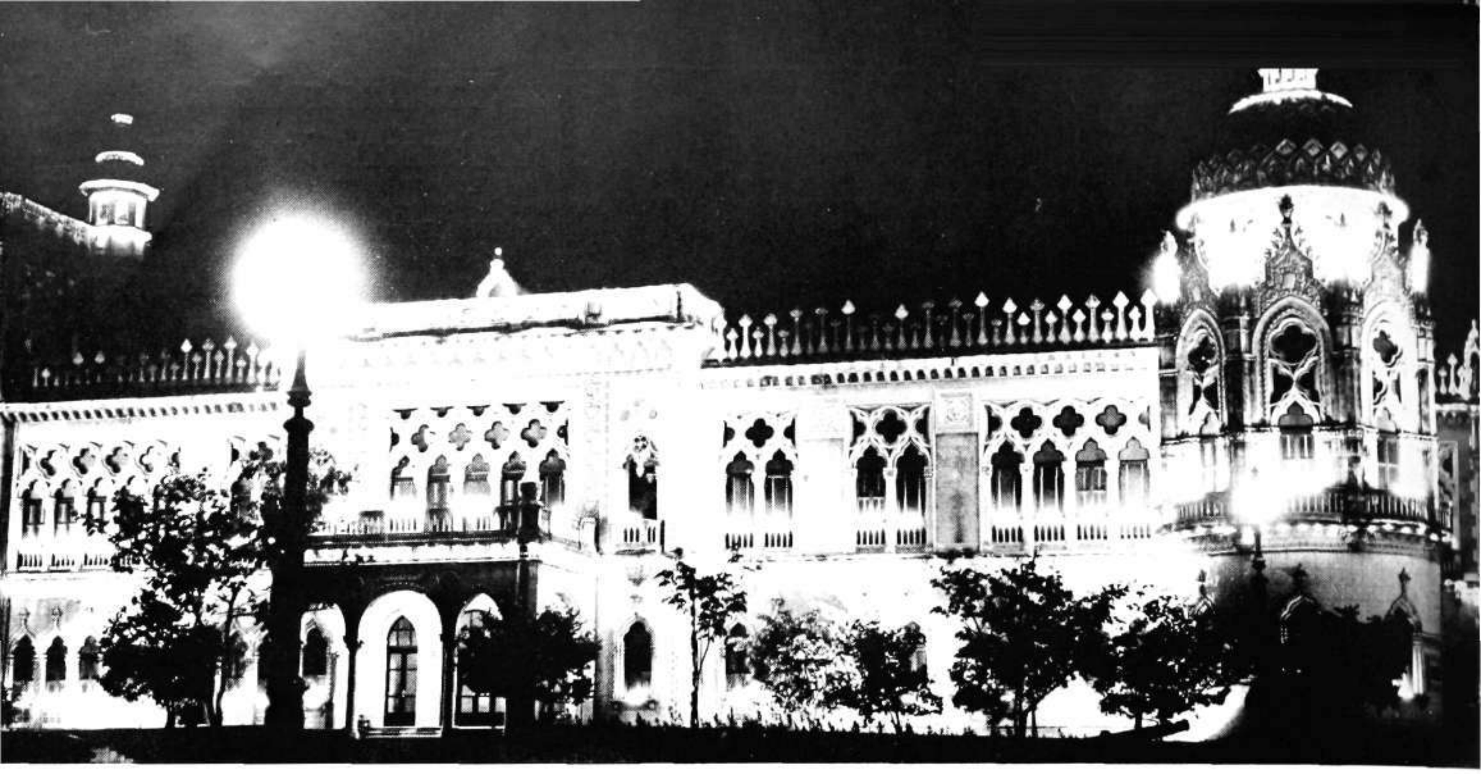
New Australian Ericsson Company

L M Ericsson has acquired a majority interest in Trimax Transformers Pty. Ltd. (Trimax), Melbourne, Australia.

After a new issue of 40,000 shares, the share capital of Trimax will be Austral. £120,000, of which L M Ericsson will own 60 per cent.

Trimax, which will change its name to L M Ericsson-Trimax Pty. Ltd., is a manufacturer of apparatus and components for the communication and electrical industries and will include suitable L M Ericsson products within its current range of manufacture.

Since 1959 L M Ericsson has won a strong footing on the Australian telephone market following the decision of the Australian Post Office to adopt the Ericsson crossbar system as standard for automatization of the Australian telephone network.



A 60-line P.A.X. of the latest crossbar type ARD 201 was recently installed in the Government Building (above) at Bangkok, Thailand. This installation, the first of its kind in the Far East, has aroused considerable attention for its rapid and reliable operation. All extensions have keyset type instead of dial type telephones.

L M Ericsson Extends Automatic Telephone Exchanges in Ecuador

L M Ericsson has signed a contract with the Ecuador government for delivery of telephone equipment to the telephone company of Guayaquil, E.T.G., for extension of the plant in the province of Guayas. Two exchanges in Guayaquil will be extended by 1,000 lines each with associated outside plant and telephone sets. The contract also covers material for pole lines from Guayaquil to Babahoyo and Quevedo in the same automatic area, as well as an automatic trunk stage type ARM for Guayaquil.

The plant, worth 3/4 million dollars, is to be mainly completed within 2 years. Since the E.T.G. opened the first section of its automatic plant in October 1955, the network has been successively increased both within the city itself and by incorporation of neighbouring towns within the automatic area.

From the start the E.T.G. has aimed at a high degree of automatic operation; and through the present contract all essential switching equipment has been ordered for fully automatic traffic with the capital, Quito.

The signing of the contract in Guayaquil: (from left) José Albán, chairman of E.T.G.; the president of Banco Central of Guayaquil; Fernando Ponce Luque, M. P.; Galo Garay, chairman of Provincial Council; Nicolás Valdano Raffo, chairman of Chamber of Deputies; Gustavo Gross, governor of Province of Guayas; Carlos Valdano Raffo, Minister of Public Works; and Galo Valverde, president of E.T.G.

Large Order for Rural Exchanges from Jutland Telephone Co.

The Jutland Telephone Co. in Denmark has placed with L M Ericsson a large order for 36 rural exchanges totalling 12,850 lines. They will be successively commissioned from January 1963 to September 1965.

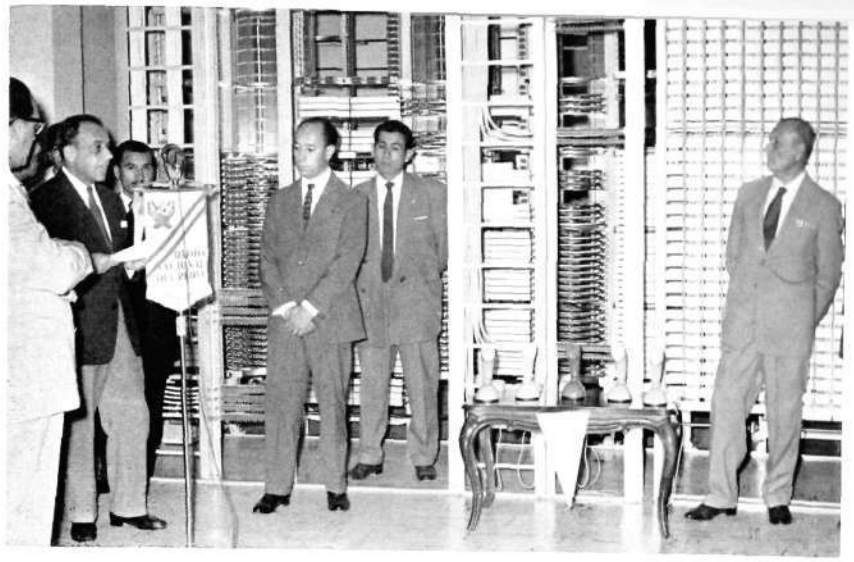
(Right) The Director General of the Jugoslavian Telecommunications Administration, Prvoslav Vasiljević, tries out the Ericofon in L M Ericsson's demonstration room on a recent visit. On his right is Ambassador Jovo Kapičić. On the far left is president Sven T. Åberg and on his right the vice-director of the Jugoslavian Administration, Slavko Markon.

A large group of finance experts from the U.S.A. visited L M Ericsson in mid-April. (Left) Some of the visitors examining an Ericovox in the demonstration room.

(Above) From left: Joseph Montlouis, Director General of the Guinean P.T.T., and L. Bangoura study the internals of the Ericofon, demonstrated by Otto Siewert, L M Ericsson, on a visit to the head factory at the end of February.

L M Ericsson's Swedish Sales Co. presented the Ericall radio paging system at the Swedish Fair in Gothenburg at the beginning of May. (Left) The Swedish Prime Minister, Tage Erlander, and the president of Ericsson Sales, T. Ericsson, inspecting the Ericsson stand.

President Rómulo Betancourt addressing the Venezuelan Congress. In the centre is seen the Chairman of the Senate, Dr Raúl Leoni, and (right) the Chairman of the House of Representatives, Dr Rafael Caldera. As is seen, the Ericofon is used within the highest administration of the state. Venezuela is an important market for L M Ericsson products. Twenty-seven automatic exchanges of 500-switch type, serving altogether 40,000 lines, have been installed — the first in 1950. In 1959 L M Ericsson signed a new contract with Venezuela for large extensions of its telephone plant. Ericsson has also supplied a large number of private telephone exchanges to Venezuela.

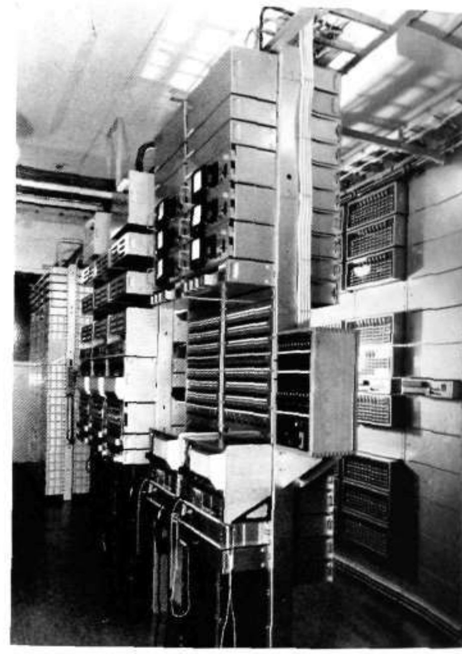


The new 500-switch exchange for Tacna, Peru, delivered by L M Ericsson. The photograph above shows the opening of this 1000-line exchange. At the microphone (left) is the chairman of Sociedad Telefónica del Peru, Sr. Neisser. On the for right is the Mayor of Tacna, Sr. Guillermo Auza.

60,000 Kronor in Year's LME Grants

The Telefonaktiebolaget L M Ericsson Foundation for the Promotion of Electrotechnical Research has made grants amounting to 19,500 Kronor from the year's funds to eleven persons.

The company's Foundation for Travel and Other Educational Grants has awarded 40,555 Kronor to 24 employees of the Ericsson Group and to six employees of the Swedish Telecommunications Administration.



The Board of Telecommunications has recently installed in Stockholm L M Ericsson's programme distribution equipment for large stations (above). This equipment, already described in Ericsson Review No. 3, 1959, is used for distribution of sound radio programmes and sound channels in the television programmes. The equipment was developed in collaboration with the Board of Telecommunications.

The head of the Rotterdam local telephone service, George Wieneke, celebrated his 40-year jubilee in the service of telephony on February 1. A reception was arranged at which gifts from near and far were presented to him. Among those who came to offer their congratulations was Eric Ericsson (right in photograph) on behalf of L M Ericsson. In the past years Mr Wieneke has cooperated intimately with L M Ericsson, especially on different problems in the field of 500-switch technique. On the occasion of the jubilee Mr Wieneke was appointed Commander of the Order of Vasa.

UDC 621.396.44
621.376.6
LME 8421, 7544

JOHANSSON, S O & RASK, B: *Transistorized Channel Modulating Equipment for Carrier Terminals.* Ericsson Rev. *38*(1961): 2, pp. 30—41.

This channel translating equipment is made according to L M Ericsson's new design principles for transmission equipment, as described in earlier numbers of Ericsson Review. The present article describes the equipment, giving reasons for the adoption of certain techniques. Performance data are given and various applications of the equipment in carrier system terminals are described.

UDC 621.395.61
621.3.029.62
LME 8512, 8042, 85102

BUCHHOLZ, L: *VHF 5-kilowatt FM Broadcast Transmitter Type 21-KK-5.* Ericsson Rev. *38*(1961):2, pp. 42—50.

The broadcast transmitter described in this article has been developed and produced by A/S Elektrisk Bureau of Oslo. The transmitter works on a centre frequency in the 87.5–100 Mc/s band. Three transmitters of this type have been put into service so far, at Kirkenes, Tana and Hammerfest in the north of Norway. A large number of others have been delivered or are under production. A 10-kilowatt type is under development, one of which is to be installed in the new combined TV and FM tower on Tryvannshöyden near Oslo.

UDC 621.319.4
621.3.015.54: 621.3.064.46
LME 1063, 8335, 7319, 7339

BORGSTRÖM, I & STERNBECK, O: *The CR Unit — a Rational Contact Protection Component.* Ericsson Rev. *38*(1961):2, pp. 51—54.

Recent developments in automatic switching technique have been followed by increased demands on the life of relay contacts. Largely for this reason AB Rifa in cooperation with the Telephone Exchange Division Laboratory of L M Ericsson has developed a new contact protector, the CR unit described in this article.

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Supervision and Maintenance Problems in a Worldwide Telecommunication Machine

E A ERICSSON, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

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This article outlines some problems of supervision and maintenance of a worldwide automatic telecommunication machine. None of the problems are new, as they already exist in national switching, but they will be more intricate and more difficult to handle on a worldwide basis. The subscribers themselves will dial more and more long distance calls without the help of an operator, and in the supervision and maintenance of the equipment many more administrations than to-day will be involved. Close cooperation between all planning, supervision and maintenance people will be essential, and some suggestions are given for integrated controlled corrective maintenance and the training of supervision and maintenance personnel, as well as the public, in order to attain the desired efficiency in the switching machine.*

Introduction

Before beginning to discuss supervision and maintenance problems, we must try to outline the main features of the machine we are going to operate. Looking into the past and the present we can draw some valuable conclusions about the future, and we find:

- ☐ The automatization of switching operations will continue, since it is profitable for all parties – the public getting lower rates and the operating enterprises better revenue.
- ☐ The effect of automatization has been a heavy growth in the number of telephones in the world; in 1960 we had more than 130 millions with an annual increase of about 7 per cent. Of these telephones about 88 per cent are automatic, fig. 1.

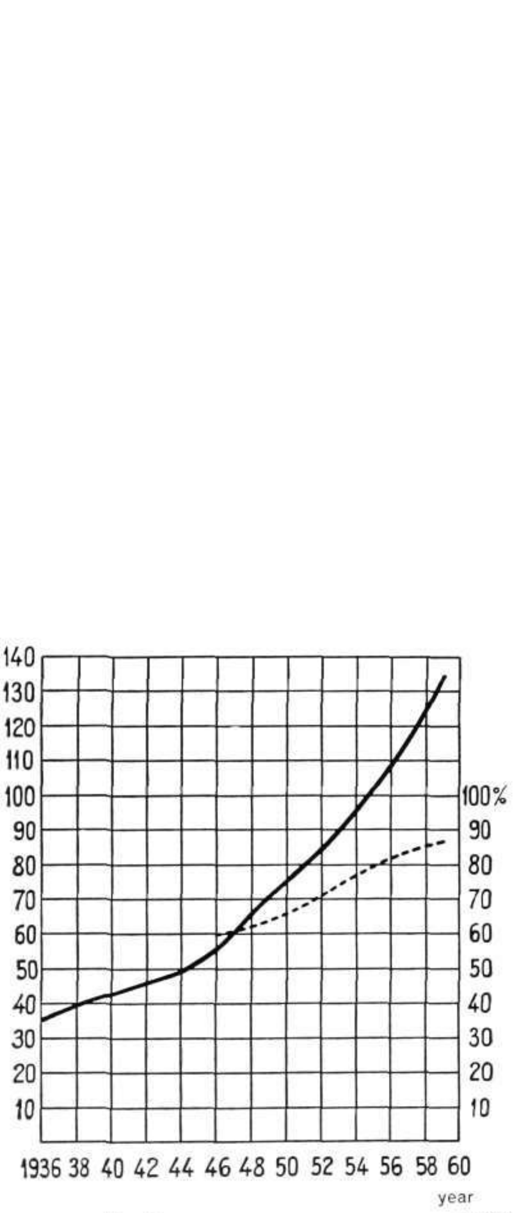

Fig. 1

Increase of the world's telephones

——— millions of telephones

- - - - - - per cent automatic telephones

- ☐ Once automatization has started, the traffic grows heavily and we become forced to automatize more and more, as it would be impossible to manage the traffic on a manual basis. The girls are needed for other tasks.
- ☐ Originally automatization covered only short distances, over which a sufficient number of physical circuits for non-delay operation could be built at a reasonable cost.
- ☐ With the development of carrier technique on wires, coaxial cables and radio links, a sufficient number of high quality long distance circuits for non-delay switching could be installed. It was then possible to reduce the long distance rates, and the effect was again an accelerated increase in traffic volume, with further need for automatization.
- ☐ Many countries already have nationwide automatization, and automatization of international circuits has started.
- ☐ After the successful submerging of the first transatlantic cable we got a number of high quality telephone circuits between Europe and North America, and there are now similar cables across the Pacific.

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* Paper prepared for the International Symposium on Human Factors in Telephony at Cambridge, England, on May 15—17, 1961, and the L M Ericsson Maintenance Conference at Stockholm, Sweden, on May 29—June 2, 1961.

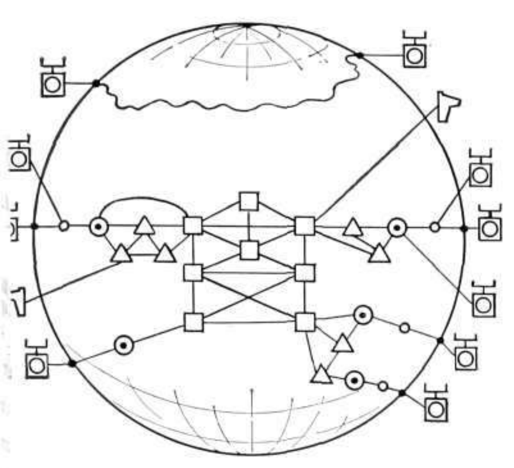


Fig. 2 X 2587 X 9152

The worldwide telecommunication machine

Subscribers' instruments

Operators

Local exchanges

National trunk exchanges

International trunk exchanges

All telephones can be interconnected via an unknown number of switching points and long distance circuits

☐ Practically all telephones of the world can nowadays be interconnected, and we have already a worldwide telecommunication machine, fig. 2. The traffic over very long distances is increasing, and the trend seems to be that new circuits become fully loaded shortly after being put in service. The explanation may be that, living in the "jet age", we expect very fast communications between countries and continents with closer relations between people and nations in business as well as private matters.

☐ People are learning more foreign languages and are not bound to their birthplace in the same way as before. To have a telephone is no longer a luxury but for more and more people a necessity, increasing with the rise in living standards. From the telecommunication point of view, we have to face a shrinking earth and take the consequences.

The Worldwide Telecommunication Machine of the Future

We can thus predict a continuous increase in the number of telephones and in traffic – the longer the distances, the heavier the increase. It is only a matter of money and time before we have a sufficient number of circuits for intercontinental non-delay operation. Whether coaxial submarine cables or "echo" or other telecommunication satellites in outer space are used for the purpose will be of minor importance. We can be sure, however, that the only way to manage the increasing worldwide traffic will be to automatize the intercontinental circuits as well, and it will not take many years before the worldwide machine is an automatic one. In fact a successful trial has recently been made between Puerto Rico and Honolulu–a distance of about 6,000 miles.

For our future machine we can predict:

☐ It will contain a large number automatic switching points linked together by physical trunks and carrier circuits in a very complicated worldwide pattern.

☐ Alternative routing will be used extensively in order to save carrier terminals and switching equipment, but also to reduce the risk of routes breaking down.

☐ Most calls will be completed by the subscribers themselves, but a lot of calls will always be handled on a one-operator basis. There may be language difficulties, or the traffic may grow faster than available circuits permit, so demanding semiautomatic switching in busy hours.

☐ For the machine, it does not matter much if the calls are made by subscribers or operators – only the latter are more skilled. No one can do much more than give the machine the necessary input orders – by means of a dial, key set or any other method that may be invented – in the form of the telephone number of the wanted party.

☐ The machine has then to take care of the given input orders and deliver the wanted output, which is to route the call according to built-in programmes over the cheapest available circuits to the wanted subscriber. In reality our machine will be a worldwide computer consisting of very many parts – telephone instruments, subscriber lines, trunks, switching and carrier equipment – of different age, design and make, the parts being owned and maintained by many administrations or operating companies.

The Public Demands

The public does not know much about our computer, fig. 3, and is only confronted with the telephone instrument and the telephone directory. But it has a lot of demands:

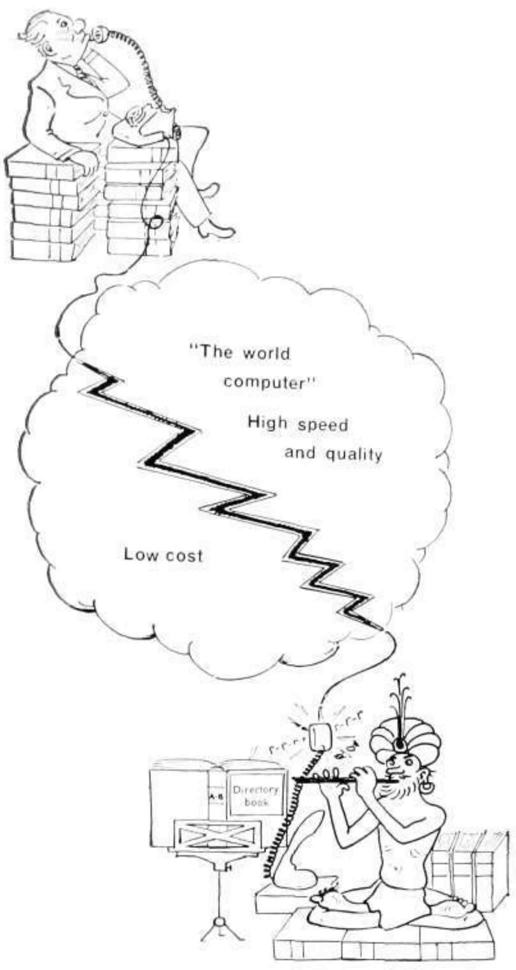


Fig. 3 X 2588

Subscribers have little knowledge about the switching machine but many demands

- ☐ high switching speed
- ☐ high reliability during switching
- ☐ high quality transmission and secrecy during conversation, and last but not least
- ☐ low rates

The public is not interested in the machine as a whole, but all the more in the quality and cost of an individual call.

Operation Quality

As for any other machine, we can never demand a fault-free worldwide computer – it would be much too expensive and cause too high rates. We have to permit some irregularities within reasonable limits. Our knowledge of the reactions of the public tells us:

- ☐ A single switching fault seldom irritates the calling subscriber – even if he gets a wrong number – as he can never be sure that he himself has not made a mistake in dialling. After an unsuccessful call the subscriber will watch his steps and will undoubtedly be annoyed and make loud complaints if switching faults are repeated. We may conclude that some switching faults of not too frequent an occurrence can be tolerated.
- ☐ Irregularities during conversation are much more serious from the point of view of the public reaction.
  - Too high a crosstalk level jeopardizes the secrecy of conversation.
  - Too much circuit noise or too low a transmission level gives too poor intelligibility, and there will be a lot of repetitions causing prolonged conversation time which the calling party has to pay for. The more expensive a call, the greater reason there will be for complaints.
  - Double connections on or breakdown of a call will certainly be complained about.

Normally the public is very patient, gets accustomed to a certain operating quality and does not complain even if there is reason to do so. Most calls are cheap and some repetitions during conversation do not matter much. In the future, however, we shall have expensive subscriber-dialled long distance calls, on which bad transmission quality will cost the caller extra money. Comparisons can be made between different parts of the world, and subscribers used to high quality will complain about calls to switching areas with too poor quality. We can thus foresee increasing public demands on the operating quality of our machine.

As two national switching networks take part in an international call, and the same equipment is used as for national calls, the operating companies must maintain an adequate quality of service for all types of calls.

For the public, quality during conversation is the most important consideration; but for operation the switching quality is also important, as all unsuccessful calls load the circuits with unpaid traffic.

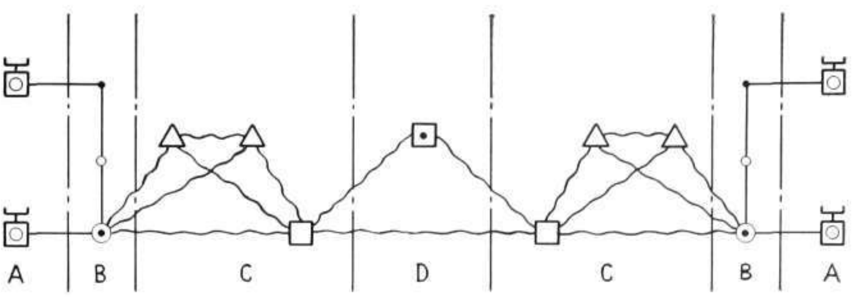
When discussing operation quality, we must remember that our machine has to carry not only telephone calls but also data transmission – we already have telex communication. On a telephone call we accept that an occasional call may be lost or that there is some unclearness during conversation, human speech having sufficient redundancy to be intelligible without too many repetitions. During telex or data transmission, signalling is continuous and any irregularity will distort the message. To prevent this, selfchecking codes – asking

Fig. 4

X 8278
X 9153

Parts of the world computer

A Subscribers' instruments and lines
B Local network
C National long distance network
D International network
Physical circuits
Carrier circuits
Local exchanges
National trunk exchanges
International trunk exchanges
International tandem trunk exchange



for repetition when there is something wrong in the received message – have been invented, but the repetitions must not be so frequent as to cause the caller extra costs. Data transmission will raise the quality demands during "conversation" still further.

Maintenance of the Machine

It is practically impossible to observe and control every one of the enormous number of calls in our worldwide computer, the parts of which are interconnected in a countless number of combinations, but in spite of that – as already stated – the machine must have sufficient operating reliability. It is not enough to supply it with high quality equipment – which can be done – but the equipment must also be maintained in the proper way.

As we can neither supervise the individual calls nor the machine as a whole – being much too big and spread over the world – we have to split the machine into maintainable parts.

Looking at a worldwide call we find the following parts, fig. 4.

- The calling subscriber's instrument and line
- A local switching network with one or more local switching points interconnected by trunks
- An outgoing trunk exchange giving access to the national long distance network, containing a number of trunk offices with intermediate carrier circuits
- An outgoing international trunk exchange for international or intercontinental carrier circuits, often with interlinked international tandem exchanges
- In the country of destination the national trunk network, local switching network, called subscriber's line and instrument

Thus, for a connection we have two telephone instruments, two subscribers' lines, a number of local, national, international and intercontinental switching points with intermediate physical trunks or carrier circuits. If many calls are made between the same two subscribers, the only equipment we can be sure of being used is the two telephone instruments and subscribers' lines. All other equipment is "common" to many subscribers – under alternative routing we do not even know which switching points will be used!

To try to trace faults other than in instruments or on subscriber's lines after a call is cleared would be as hopeless as trying to find a needle in a haystack. We must look for other methods and try to find any sources of systematic or serious faults before the public reacts.

We must also consider that a worldwide call passes the equipment of many administrations, the maintenance of which is carried out by groups of specialists. Traditionally we have sections for the maintenance of

- ☐ instruments, subscribers' lines and physical trunks
- ☐ local exchanges and trunk exchanges
- ☐ transmission equipment and carrier circuits

Even within one administration there may be difficulties if the specialists know too little about the other maintenance fields. Many faults are repaired much too late, as the source is considered to belong to another section – this is human but dangerous for the service quality. In our world machine such difficulties will increase heavily, and we have to find methods for worldwide integrated maintenance with very close co-operation between all maintenance parties involved.

We have two main problems:

- ☐ How to know if there are too many faults in our machine – supervision
- ☐ How to trace and remove the faults – maintenance

We can consider our world machine as an automatic factory producing telephone calls. In modern manufacture we use statistical methods for product control – supervision – and adjust the manufacturing process – maintenance – when the level of quality falls too low. We cannot warrant that every part is perfect, but we can warrant that the fault rate is kept within permissible limits, giving sufficient quality in the total product.

Let us now investigate our means of supervising and maintaining some important parts of our telecommunication machine.

Automatic Telephone Exchanges

In earlier days we always had "preventive" maintenance with routine testing, adjustment, cleaning and lubrication. On top of that we had fault tracing when subscribers' complaints were received or irregularities were observed. All these activities called for many maintenance people in an exchange and were expensive, and the result was often not too encouraging, as the maintenance people cause too many casual faults which they hunt for in vain and so possibly set up new faults in the process – with results in a vicious circle.

We have now learnt our lesson and found that "controlled corrective" maintenance gives a much better result, especially on switching systems which have long life and are stable and reliable. The rules are now:

- ☐ Do not touch the equipment unnecessarily
- ☐ Keep people out of the switching room as far as possible
- ☐ Keep the switching room closed and clean
- ☐ Let the maintenance people supervise the exchange from outside the switching room
- ☐ Give them the necessary supervision equipment enabling them to control the operating quality on a statistical basis without entering the switching room
- ☐ Take no action as long as the fault rates are below prescribed levels
- ☐ Train people to use the statistical information so as to know how and where to find a fault before entering the switching room

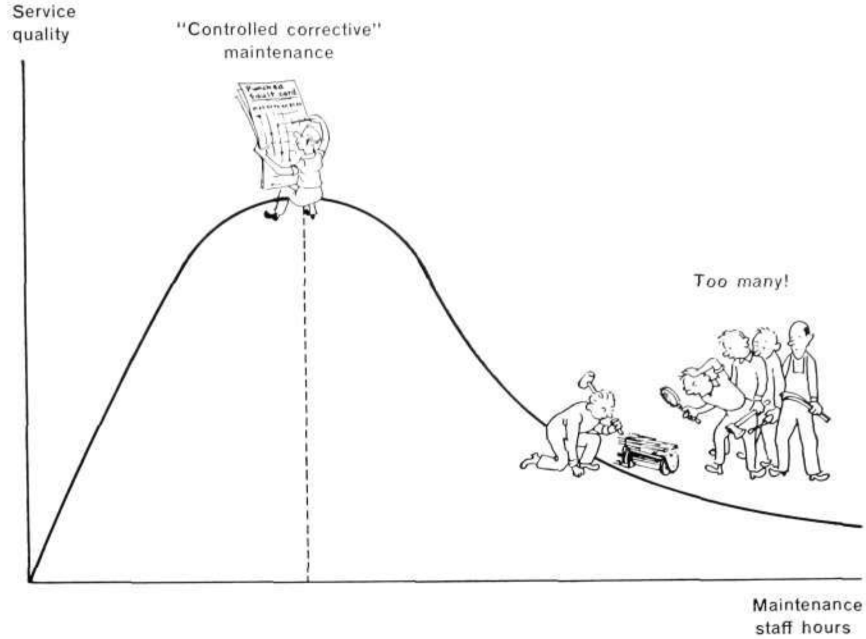


Fig. 5 X 8279

Service quality in relation to maintenance cost

Too many people can jeopardize service quality.

In other words keep the "human factor", which causes casual, untraceable faults, out of the switching room, fig. 5. Many administrations are following this maintenance philosophy with excellent results, that is with more reliable operation at lower cost.

The most important supervision equipment is the "traffic route tester", which controls calls through one or many exchanges. Use can be made of artificial calls switched in the same way as a subscriber would have done, or one can monitor subscriber calls at random.

Many switching systems have common control. The common control equipment can be economically equipped with special checking circuits, which make it possible to record all troubles during switching. In such case the traffic itself delivers to the maintenance people a lot of trouble data which can be treated statistically.

Telephone Instruments and Subscribers' Lines

Faults in individual subscriber equipment will sooner or later jeopardize switching or transmission quality. As subscribers are often too patient, we cannot rely on subscribers' complaints alone but must use some form of controlled corrective maintenance of components subject to deterioration in respect of

- ☐ line resistance, leakage and noise
- ☐ dial speed and ratio
- ☐ transmission quality of telephone transmitter and receiver

We already possess certain facilities which simplify fault tracing and the control of subscribers' equipment, such as

- ☐ "Test switches" over which the wire chief can automatically switch any subscriber line of an exchange or group of exchanges to his desk, where he can check the line conditions and dial performance with the subscriber's help. A large number of lines in succession can be automatically controlled in respect of leakage – with recording of lines which are outside predetermined limits. Normally this equipment is used only after complaints have been received and provides no statistical quality control.

☐ "Control registers" are a type of monitoring device for connection at random to link circuits in the automatic exchange on initiation of a call. They check the line conditions and the dial. They cause no disturbance to the subscriber, as they operate during normal dialling. Lines or dials which have suffered too great deterioration are recorded on punch cards, together with the type of fault, long before they can impair the switching reliability. The cards can be treated statistically and so provide the line maintenance people with valuable data for controlled corrective maintenance of certain essential components in the subscribers' circuits.

☐ "Telephone transmission tester". New telephones undergo very severe tests before leaving the factory to make sure that they fulfil the CCITT recommendations. But we know very little about their deterioration after installation at the subscriber's premises. The subscriber is very patient and becomes used to a successive deterioration without complaining. Many telephones in service have undoubtedly too poor a quality of transmission without being reported, which can cause troubles for the subscriber at the other end. We have no means for automatic testing of transmission performance, but we can give the line maintenance people a small portable transmission tester which they can use in combination with measuring equipment at the wire chief's desk when visiting subscribers for other reasons.

Long Distance Circuits

As long as the long distance circuits are operated manually, the operators can change to another circuit when the transmission conditions are too bad, and they can also be given devices for regulating the transmission level on individual long distance calls. With subscriber dialling these possibilities disappear, and we must have stable transmission levels on automatic long distance circuits. Furthermore, in our long distance network an unknown number of circuits will be alternatively interconnected over intermediate trunk exchanges. As we can no longer supervise and regulate the transmission conditions for individual calls over many unknown circuits in sequence, the stability and quality demands on every component – the individual circuits – must be very high, and the tolerance variations with time must be kept small.

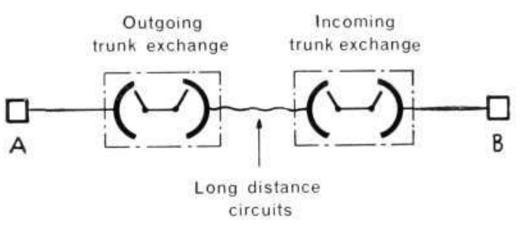


Fig. 6

Automatic transmission testing

A Calling device
B Answering device

In the carrier systems we have pilot frequencies with automatic level regulation for groups of carrier circuits, but that is not enough. We must have a sufficient number of test data to enable us to make a more accurate statistical analysis of individual circuits and groups of circuits. To do this manually would be expensive, and we must also consider the casual faults caused by the human factor. From telex traffic we have learnt that the fault rate increases when there are people in the repeater rooms. In the same way we shall avoid trouble if the transmission equipment can be supervised from outside the equipment rooms.

For this purpose the trunk exchanges can be arranged to function as large test switches for automatic supervision of the long distance circuits (fig. 6). The transmission people can, so to speak, borrow the trunk exchanges for automatic switching of their own test equipment to the sending and receiving end of a long distance circuit. Circuit after circuit can then be automatically supervised quickly and cheaply on a built-in programme, the results being recorded on punch cards suitable for statistical analysis.

In a similar way the switching people can borrow the transmission circuits for sampling test results to control the reliability of the trunk exchanges themselves.

Supervision of Traffic Capacity

For the public it is of minor importance whether the reason for an unsuccessful call is a technical fault in the switching equipment or a lack of circuits – the sum of both must be kept within acceptable limits.

In our worldwide machine we therefore need some form of traffic load supervision, the purpose of which would be to sample the necessary statistical information for

- ☐ the planning people to analyse and predict the growth in international traffic so as to plan and install new equipment and carrier circuits
- ☐ the accounting people to split the traffic revenue between the operating parties concerned.

These problems are being investigated by a CCITT study group, which is trying to find a satisfactory method of accounting which will not be too expensive nor too complicated. An acceptable solution seems to be that

- ☐ the world should be divided into number of international rate areas, consisting of a country or parts of a large country,
- ☐ in every country there should be one or more international border switching points,
- ☐ in these switching points the traffic load to all international rate areas should be metered automatically for every outgoing international route.

The metering of all areas on all routes is necessary as, with alternative routing, international calls may be passed through a number of countries all of which ask for their share of the revenue.

The statistical figures necessary for the accounting people, supported by figures of congestion on the routes, will give the planners valuable information for their work. Again we have two parties – accounting and planning – partly using the same "tools", the statistical information about the traffic, the sampling of which they have to plan together. The accounting people are "producing the revenue" which enables the planners to install sufficient new equipment on the right spot. In a worldwide telecommunication machine planning for the future is very complicated, and again close cooperation between the planning parties concerned is the only solution.

Conclusions

In the foregoing some problems of supervision and maintenance of a telecommunication machine have been touched upon. None of them are new, as we already have them in national switching, but they will be more intricate and more difficult to handle on a worldwide basis. The subscribers themselves will dial more and more long distance calls without the help of an operator, and in the supervision and maintenance of the equipment carrying those calls many more administrations than to-day will be involved. Gradually we have to find better and better methods to ensure that the machine operates efficiently. We have to count on two main human factors:

- ☐ The public – with its reactions and demands – which delivers to the machine its input orders without any knowledge of its function. We cannot select the subscribers, but must teach them to use the machine in the proper way, as subscribers' mistakes – similarly to technical faults – jeopardize the efficiency of the machine. Telephone directories normally contain a lot of instructions about

*—105967

· how to find a telephone number

· how to dial local and long distance calls

· the meaning of tones

· how to hold the handset and how to talk

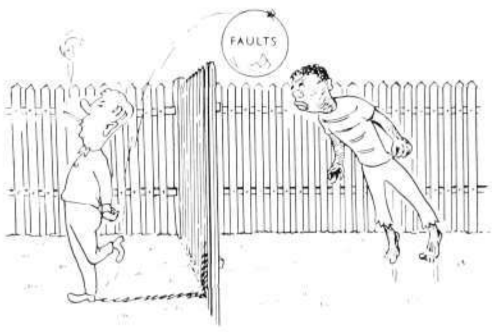
But many people do not read the instructions. Of course we have means of discovering unsuccessful callers in our machine and giving them additional instructions, but it is no easy task to teach subscribers the correct behaviour in this way. A good idea might be to start training children at school as part of their general knowledge curriculum – how to fill in forms, how to write a letter, how to cross a street, how to vote, etc. Why not include the proper use of the telephone? The children would certainly be interested and could pass on their knowledge to their elders.

□ The supervision and maintenance personnel, whose job it is to take care of subscribers' complaints as well as the service reliability of the telecommunication machine itself. We have to consider:

· The necessity of giving the maintenance personnel efficient and sufficient supervision and testing equipment, enabling them to sample and use data of fault rates and service quality and providing means of controlled corrective maintenance at a reasonable cost.

· The necessity of close cooperation between supervision and maintenance parties within or between administrations and operating companies.

· Selection and training of supervision and maintenance personnel to ensure that they do a good job without too many human errors.



Do not kick own faults to another party, but . . .

. . . help other parties to solve problems!

Fig. 7 X 2590

Cooperation is necessary

In a worldwide machine the cooperation between all parties involved is very important, fig. 7, and they must have a good knowledge of their common problems and be willing to help each other. A good way seems to be to let them borrow one another's equipment for making automatic tests. It is quite natural to place the switching people – who are used to automatic equipment – as a link between the line and transmission sections. There will always be some bickering about whether faults originate in one's own or the other fellow's equipment. But such discussions can be very useful, as one part can give valuable hints to the other and in the long run better and closer cooperation can be assured.

We must also face the fact that the introduction of the controlled corrective maintenance philosophy will place new demands on maintenance personnel. In earlier days they were skilled mechanics, many of them with very little knowledge of advanced switching and transmission. We can now build increasingly reliable equipment, requiring less mechanical adjustment, and in future we shall have more and more electronic equipment – also for switching – without possibilities of mechanical adjustment. We shall then need less maintenance personnel, but of another type than to-day, as many activities will be automatized, as is now being done in the factories. Great care must be given to the selection and training of personnel; they must know something about mechanics, but more about switching, transmission, electronics and statistics. They must be trained to use and keep statistical records in the proper way. Furthermore, being few in number, they must be paid for their knowledge and their ability to do a good job.

Pulse Generator for Testing Switches and Relays

B LARSSON & Å SVENSSON, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

UDC 621.373.44
LME 7559, 1528

For the testing of switches and relays and of automatic telephone exchange equipments containing switches and relays, a device is needed which can close and open circuits a given number of times at a given frequency and with a given make-break ratio. To meet this requirement, Telefonaktiebolaget L M Ericsson has developed the pulse generator ZYH 20201 presented in this article.

Fig. 1 X 2506
Pulse generator ZYH 20201 in use

The pulse generator *ZYH 20201* generates break or make pulses at frequencies from 2 to 100 c/s and with adjustable make-break ratio. The apparatus can be used for continuous pulsing or generation of pulse trains which are repeated at adjustable intervals. If set to an infinite interval, the pulse train can be started manually or by means of an external make contact. Only one pulse train is obtained on every start. The number of pulses in a train can be varied between one and thirty. Using a separate auxiliary set *ZYY 10201*, up to nine different trains of max. ten pulses each can be preset simultaneously. The trains can be started manually with a push-button or with an external make contact, being generated in a predetermined sequence. The interval between trains can be selected from 100 to 1,100 ms in steps of 10 ms.

Principle

The pulse generator consists of the block units in fig. 2.

The generator frequency is determined by an RC circuit and is obtained by varying the resistance. The output voltage is saw-toothed and feeds a level-sensitive output stage containing two mercury relays. Change of the trigger level of the output stage provides different make-break ratios on the contacts of the pulse relays. In the generator is set for sending of pulse trains, the number of pulses is counted by a binary chain which stops the generator after

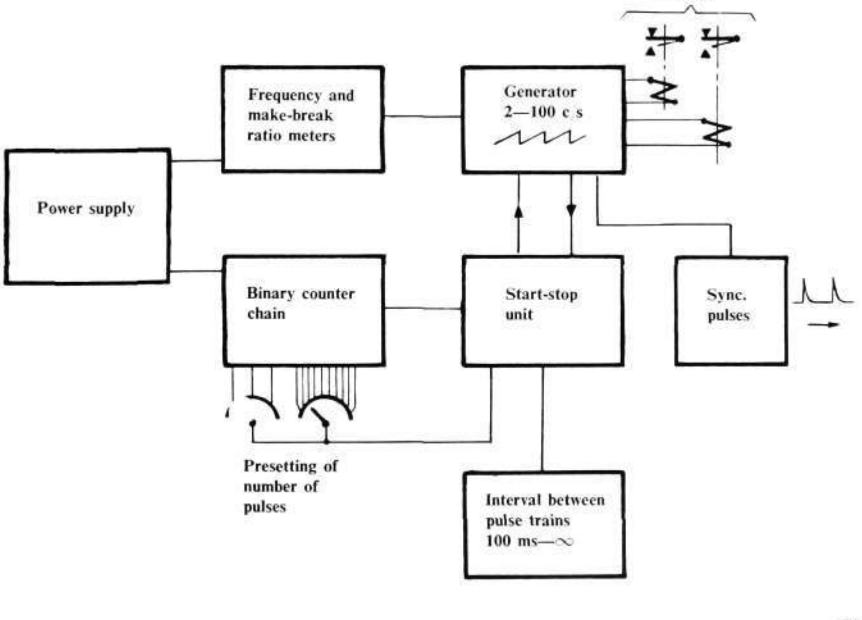


Fig. 2 X 8294
Block schematic of pulse generator ZYH 20201

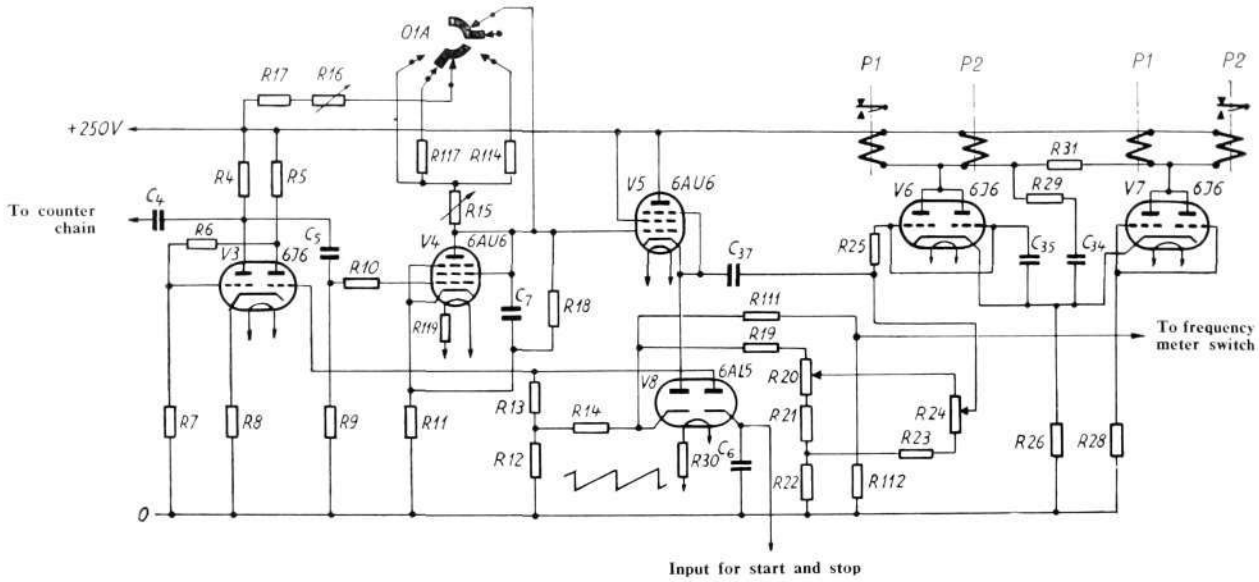


Fig. 3 X 7822

Generator circuit with variable pulse width

the set number of pulses has been obtained. A special timing circuit, containing an RC circuit and a cold cathode tube, restarts the generator after the set interval, which can be varied from 100 ms to ∞. The counter can be disconnected so as to obtain continuous pulsing. A positive synchronizing pulse is obtainable from a level-sensitive trigger circuit. This pulse can be set to any desired phase position.

Generator

The generator contains a frequency-determining RC circuit – capacitor C_7 and charging resistors *R 15*, *R 16*, *R 17* and *R 117* (fig. 3) – followed by a cathode follower, tube *V 5*. The output of the cathode follower, which reproduces the voltage level on capacitor C_7, is connected to a trigger circuit, tube *V 3*. This renders discharge tube *V 4* conductive when the voltage across capacitor C_7 has attained a given level. The capacitor is thereupon quickly discharged, after which *V 4* is again cut off and a new charging cycle starts. Tube *V 8* serves as gate circuit for start and stop signals. Tubes *V 6* and *V 7* are interconnected in a flip-flop circuit controlled by the cathode follower. When the input voltage becomes positive, the flip-flop circuit switches to ON at a given level. It switches to OFF when the voltage becomes negative again on discharge of capacitor C_7. The input voltage from the cathode follower to the flip-flop circuit can be regulated with two potentiometers, *R 20* and *R 24*, whereby the point of operation can be shifted so as to obtain the desired relation between ON and OFF. The pulse relays *P 1* and *P 2* are connected into the anode circuits of the tubes (*V 6* and *V 7*).

The use of this principle means that the make-break ratio on the pulse relay contacts can be varied with potentiometers *R 20* and *R 24* without affecting the frequency. Each of pulse relays *P 1* and *P 2* has a make-before-break contact.

Binary Counter Chain

A binary chain is used for counting the number of pulses in the trains. The end position of the chain is fixed, while its starting position is dependent on the number of pulses desired. When the generator starting key is depressed, a negative presetting pulse proceeds from tube *V 14* and positions the chain on the starting position determined by the selector switches (fig. 4). The chain is stepped by the generator trigger circuit, tube *V 3*.

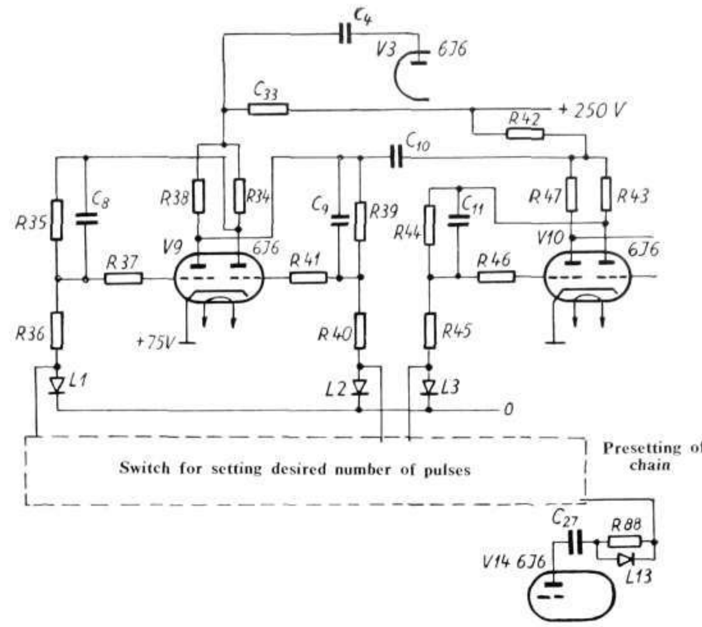


Fig. 4 X 8285

Binary counter chain

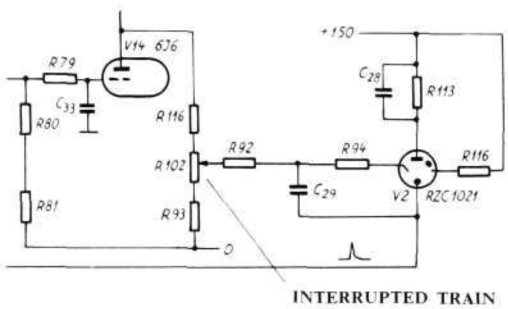


Fig. 5 X 2596

Circuit for generation of pulse trains

When the chain reaches the end position, a stop signal is sent from the last stage to gate tube *V 8* (fig. 3).

Generation of Repeated Pulse Trains

When the generator is set for interrupted pulse trains, a timing circuit containing tube *V 2* comes into operation (fig. 5). This circuit is actuated by the end position of the counter chain and, after a preset time, delivers a new start pulse. The time setting is effected with *R 102*.

Synchronizing Pulse Circuit

The synchronizing pulse is intended primarily for synchronization of an oscilloscope. Fig. 6 shows the structure of the circuit. It is controlled from the cathode follower, tube *V 5*, in the generator. When the input voltage becomes positive, the trigger circuit switches to operate position, so providing a differentiated positive output pulse. The operate position can be set with potentiometer *R 27* which is so designed that the operate position can be shifted throughout an entire cycle.

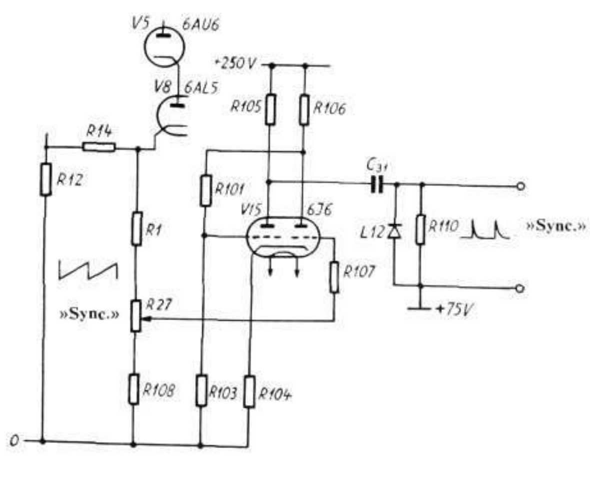


Fig. 6 X 8286

Circuit for synchronizing pulse

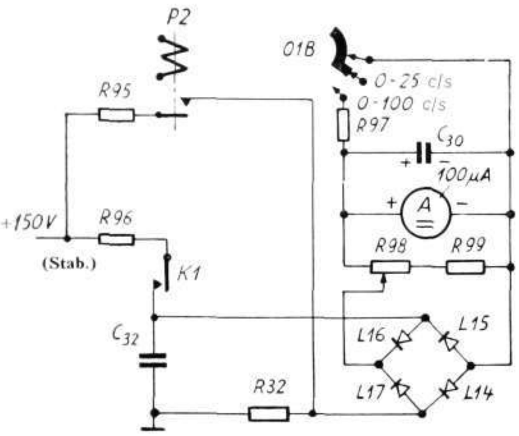


Fig. 7 X 2597

Principle of frequency meter

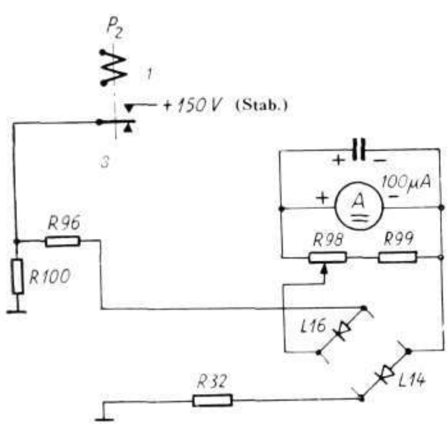


Fig. 8 X 2598

Principle of make-break ratio meter

Frequency Meter

The circuit diagram of the frequency meter is shown in fig. 7. The operation of the pulsing contact on relay *P 2* charges and discharges capacitor C_{32}. The alternating current through the capacitor is rectified and led to a moving coil instrument. The instrument shows the rectified mean value of the current. Since the charging and discharging time of C_{32} is short compared with the cycle time, the deflection of the instrument is proportional to the frequency. Capacitor C_{30} smooths the instrument current so that a stable pointer deflection is obtained even at low frequencies.

Make-Break Ratio Meter

The circuit diagram of the make-break ratio meter is shown in fig. 8. The pointer instrument is graduated from 0 to 100. When contact 1–3 is closed, the instrument is calibrated at full deflection (= 100 %) with potentiometer *R 98*. The mean value of the pulsing current passing through the instrument is directly shown on the dial. The reading indicates during what percentage of the cycle the pulse contact is closed.

The make-break ratio meter can be connected by means of a key to the make or break contact of relay *P 2*. There are also facilities for connecting it to an external contact through the "% METER" terminals.

Mechanical Construction

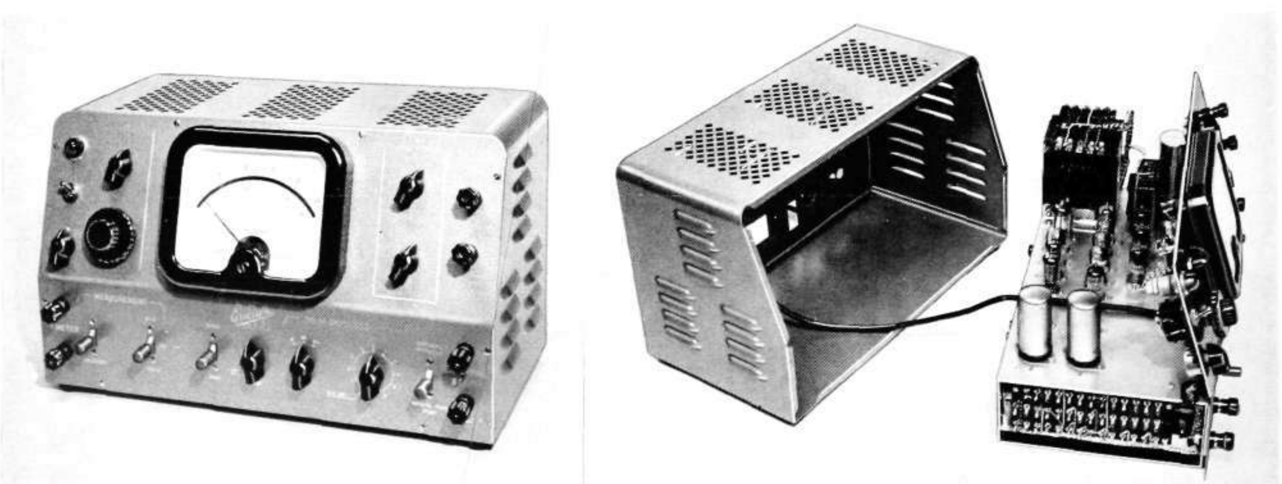
The general appearance of the pulse generator is shown in fig. 9. The chassis is attached to the front panel. For inspection or tube replacement the front panel can be unscrewed and the cover withdrawn.

Applications

The frequency scale has two ranges, 0–25 c/s and 0–100 c/s. The required range is selected with a knob, which at the same time sets the generator to the same range. Within each range the frequency can be continuously adjusted with two knobs, a coarse and a fine knob. The make-break ratio can also be set with two knobs, a coarse and a fine. The generator contains two

Fig. 9 X 7821

Pulse generator ZYH 20201 (right) with cover removed



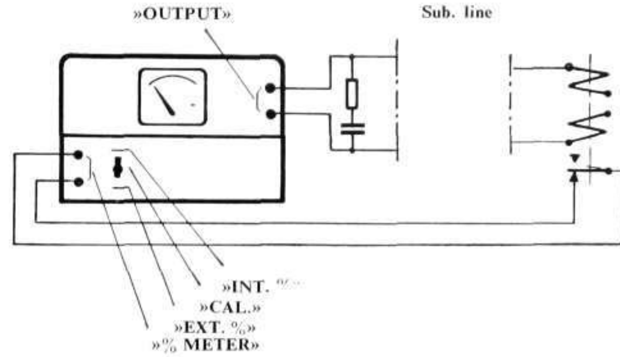


Fig. 10 X 8287

Connection for measurement on pulse relay

pulse relays, each of which has a make-before-break contact. The relays are connected to jacks on the rear of the apparatus. By means of a key one make-before-break contact can be disconnected and its make or break side can be connected to two "OUTPUT" terminals on the front panel. There are two keys for connection of the frequency meter and make-break ratio meter. The latter meter can be connected either to measure the make-break ratio from the two "OUTPUT" terminals, or to measure external contacts via the two "% METER" terminals. Measurement on these contacts can be done at the same time as pulses come from the generator (see examples below).

Two knobs, one for tens digits and one for units digits, are used for setting the number of pulses in a train. The units digit knob has a special position for connection of the auxiliary set *ZYY 10201*.

For generation of continuously repeated pulse trains, the length of the interval between trains can be regulated with a knob. When the knob is set to infinity, individual pulse trains can be started manually with a key or with an external make contact. The opposite position of the knob produces continuous pulsing.

There are sockets on the rear of the apparatus for supplying synchronizing pulses to an oscillograph. The phase position of the synchronizing pulse is set with a knob on the front panel.

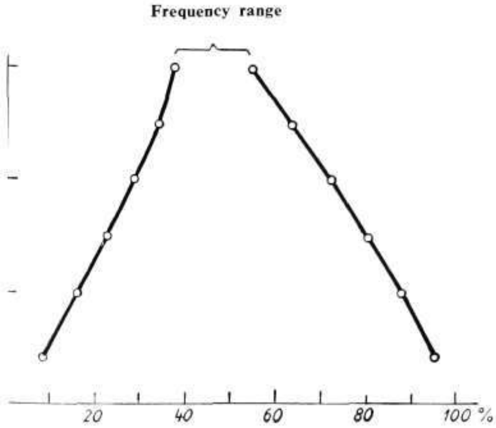


Fig. 11 X 2599

Pulsing curve for step-by-step switch

Examples of Applications

1. Connection for measurement of pulse relay

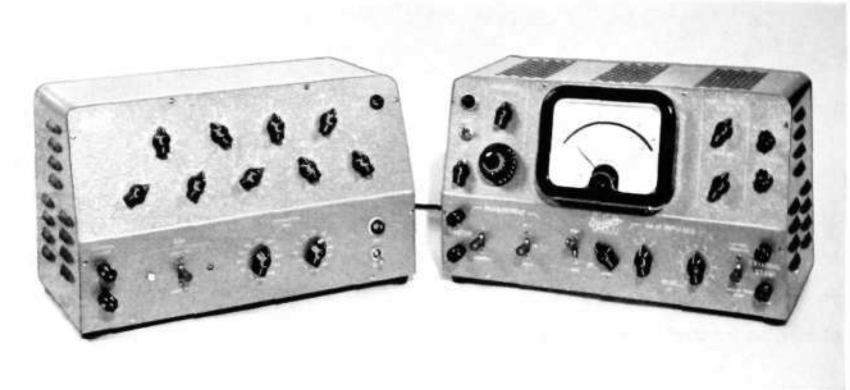
For measuring the distortion of a pulse relay when pulsing at different frequencies and make-break ratios, and possibly with other external variables such as length of line and battery voltage, connection can be made as in fig. 10. After the pulse generator has been set for a given frequency and given make-break ratio, the lever key is thrown to "EXT. %", after which the make-break ratio of the relay can be read off the instrument.

2. Determination of functional limits for a step-by-step switch in respect of the make-break ratio of the driving contact

For every frequency setting the make-break ratio is increased and decreased until the stepping of the switch deviates from the number of pulses set on the generator. The limits are noted. See fig. 11.

Fig. 12 X 8282

Pulse generator ZYH 20201 with auxiliary set ZYY 10201 for sending of nine different pulse trains



3. Determination of functional limits for the digit-receiving parts of a register

For this measurement the auxiliary set *ZYY 10201* must be used with the pulse generator. Pulsing speed and make-break ratio are varied on the generator. The desired digit combination and the length of interval between digits are set on the auxiliary set. The possibility of varying the length of interval can be used to determine how quickly the equipment is switched for reception of a new digit.

Auxiliary Set ZYY 10201

If it is desired that a given number of pulse trains shall be generated in a sequence and that it shall be possible to preset the number of pulses in each train, use is made of auxiliary set *ZYY 10201* (figs. 12 and 13). With this auxiliary set, up to nine different pulse trains of max. ten pulses each can be preset simultaneously. The interval between trains can be varied from 100 to 1,100 ms in steps of 10 ms.

The auxiliary set contains mainly a relay chain, a control circuit for the relay chain, an interval timing circuit, and a mains power unit. The purpose of the relay chain is to count the number of pulse trains and successively to switch into circuit preset selector switches for determination of the number of pulses. The pulse trains can be started manually by means of a push button on the front panel or from an external make contact.

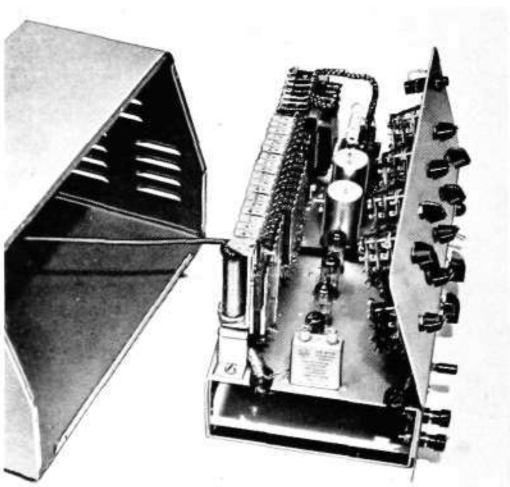


Fig. 13 X 2593

Auxiliary set ZYY 10201 with cover removed

Technical Data

Electrical data, tubes, dimensions of pulse generator ZYH 20201

Power supply: 110, 127, 220 and 240 volts, 50–60 cycles

Power consumption: approx. 60 watts

Dimensions: 400 × 240 × 230 mm

Weight: approx. 15 kg

Pulse contact loading: 2 A, 100 V, max. 100 VA. Inductive loads require contact protection. The pulse contacts are free from bounce. Two make-before-break contact actions can be obtained simultaneously. The time lag between the make and break actions does not exceed 1.5 ms.

Frequency: 2 — 100 c/s.

Make-break ratio: 5 — 95 % at 10 c/s

$$\text{Make-break ratio} = \frac{t}{T} \cdot 100\ \%$$

t = length of make pulse
T = length of cycle

Number of pulses in a train: 1—30

Continuously variable interval between trains: 100 ms—∞

Positive synchronization for oscilloscope can be varied throughout a whole cycle

Accuracy of frequency meter and make-break ratio meter: ± 3 % of full deflection

Tubes: ten *6J6*, two *6AU6*, one *6AL5*, one *OA2*, one *RZC 1021*

Electrical data, tubes, dimensions of auxiliary set ZYY 10201

Power supply: 110, 127, 220 or 240 volts, 50—60 cycles

Power consumption: about 60 watts

Dimensions: 400 × 240 × 230 mm

Weight: about 10 kg

Number of pulses in one train: 0—10

Number of pulse trains in a sequence: 0—9

Intervals between trains: 100—1,100 ms in steps of 10 ms

Tubes: three *6J6*, one *OA2*

Intercom System for Hotels and Motels

H EKSTRÖM & A TRÄGÅRDH, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 621.395.22
LME 8371

With the growth of travel, and in particular motoring, new hotels and motels are springing up everywhere. Especially the small ones wish for a cheap and simple system of intercommunication between residents and reception office and, in place of a large P. A. B. X. with telephones having access to the public network in every room, a few such instruments at suitable locations.

L M Ericsson has designed a system which, through its rapidity, capacity and other operational properties, fulfils the needs of small hotels and motels. The system is also well suited for schools and factories with similar requirements.

Hotels and motels require a telephone system which enables residents to telephone an order, for example, to the hall porter, who can then immediately forward it to the person concerned. This saves time for the residents and much running about for the hotel staff.

When the system is used in schools or offices, it is often desirable to provide for paging facilities or for public announcements from the master set. In both cases this can be done via loudspeakers.

The system consists of master set, a number of telephone sets, cabling and power equipment.

Main Features

The master set (fig. 1) is made in three sizes for 21, 33 or 57 lines, and is of desk type.

The clean lines make the grey-enamelled metal case with light-grey plastic sides fit well into any environment. A 6-ft. flexible cable with wall terminal box connects the set to the remainder of the system.

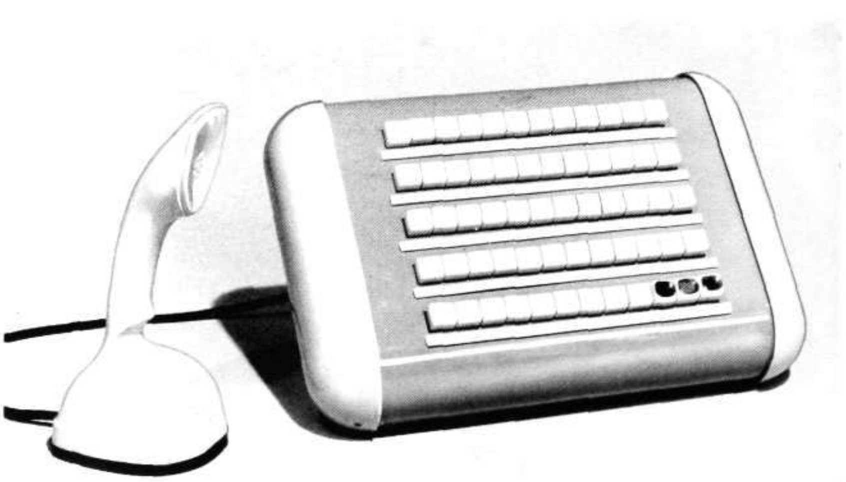


Fig. 1
Master set DEA 10201
for 57 lines

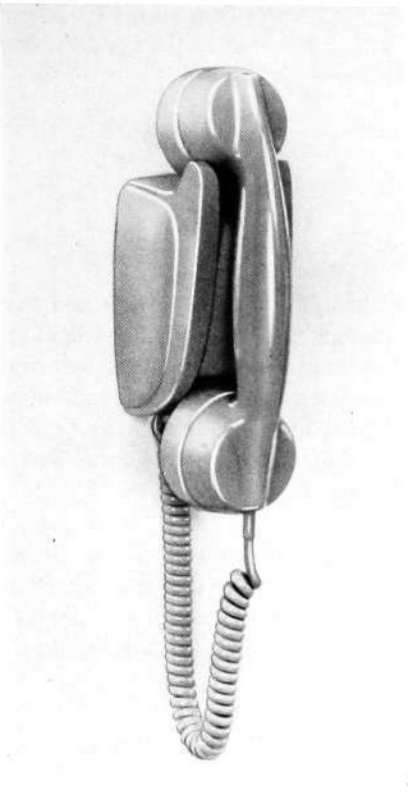


Fig. 2 X 2594
Telephone set DEP 4041
in light-grey melamine

Calls are indicated by the lighting of lamps and are set up with push buttons. The lamps are placed inside the buttons under a transparent cap. There is also a light-red button for signalling to extensions, a dark-red button which gives a louder signal, and a green speak-listen button for use when the system incorporates loudspeakers with answering facility. A lamp in the light-red signalling button lights as a sign that a line button is depressed – this as a reminder to restore the button after conversation.

Repeated signals are obtained from bells or buzzers connected to the master set.

Designation strips are provided on the master set for indication of telephone or room numbers. The strips can be easily removed for change of any designation.

The master set has no conventional handset. Conversations with extensions are conducted on a separate Ericofon.

The room telephones (fig. 2) are of wall type in light-grey plastic case and with light-grey plastic handset with coiled cord. When the handset is lifted, it actuates a springset which initiates a call to the master set. On a call from the master set a signal is extended which actuates the diaphragm of the telephone receiver. The receiver diaphragm thus acts as signalling device.

The line resistance may be 300 ohms, that is 150 ohms in each branch of the two-wire line.

Loudspeakers can be connected to the system for paging purposes and for public announcements. The loudspeakers terminate on a relay set with amplifier. The relay set, which is connected to the system in the same way as a room telephone, can be made either for loudspeaking calls only from the master set or to allow for an answer to be returned from the loudspeaker to the master set.

The cabling between the telephones and the master set consists of two-wire lines of ordinary telephone type with plastic insulation. The lines terminate on the master set terminal box, which at the same time serves as distribution box. It has convenient screw terminals which make connection simple. In the telephone sets the lines terminate on a terminal block within the casing.

The relay set for connection of loudspeakers has a four-wire cable to the master set.

The power supply comes either from the mains via a battery eliminator or from a 24 V battery. The consumption is quite negligible, the maximum d. c. consumption at nominal voltage being only about 0.5 A.

Installation

In a hotel or motel a telephone is installed in each room. The master set is placed on the reception desk, with an attendant, or at any other point from which centralized communication is required. The cabling is simple and the equipment easily installed. The cost of installation and maintenance is very slight

in proportion to the range and capacity of the system. In a school the master set is usually placed with the caretaker, with telephones in the head master's office, the library, classrooms and other locations.

Operation

All calls are secret.

A call from the master set is made by first lifting the Ericofon and then pressing the button of the wanted line. For an ordinary signal the light-red signal button is pressed. If a louder signal is desired – to awaken a resident or to ring a number where ordinary signals are difficult to hear – the dark-red button is pressed instead. The extension answers by lifting the handset. At the end of conversation the extension replaces the handset and the line button on the master set is pressed once again to clear the line.

Should the extension not answer immediately, the line button can be left depressed and the Ericofon put down. The master set user can then attend to other business while waiting for the answer. When the extension later lifts his handset to answer the call, an intermittent audible signal is heard at the master set. On lifting the Ericofon this signal ceases.

A call from an extension is made by lifting the handset, whereupon the calling line lamp on the master set lights and an audible signal is heard. It is answered at the master set by lifting the Ericofon and pressing the calling line button. At the end of conversation the extension handset is replaced, the line button is restored and the Ericofon put down.

Longest C.T.C. Line in Europe

SVEN LUNDGREN, CHIEF SIGNAL ENGINEER, SWEDISH RAILWAYS, STOCKHOLM

UDC 656.25
LME 86

C.T.C. has become an acknowledged and increasingly employed means of modernization of operations on the Swedish State Railways, which in January 1961 opened the first section of what will be the longest C.T.C. line in Europe, between Ljusdal and Mellansel on the main route between Stockholm and Boden. Mr. S. Lundgren, the Chief Signal Engineer of The Swedish State Railways, gives an account of the technical principles which the Swedish, Norwegian, Danish and Finnish Railways have considered necessary for operation of C.T.C. plants and describes, firstly, two important C.T.C. plants installed prior to the Ljusdal–Mellansel system, followed by a fuller description of the latter installation. He also gives some account of the future plans of the Swedish Railways. He does not deal with the technical aspects of the C.T.C. system, since these have been described in earlier articles in Ericsson Review (No. 4, 1954, No. 2, 1958, and No. 3, 1960).

The first C.T.C. system in Sweden was installed in 1938 on the Stockholm–Staltsjöbaden line. Plans for additional C.T.C. installations were interrupted by the war. After the war a committee of the Swedish, Norwegian, Danish and Finnish Railway Associations was appointed to study problems of centralized

Fig. 1 X 7823

C.T.C. office, Ånge

Note the two traingraphs built into the control desk

traffic control and in 1953 presented proposals for technical principles for C.T.C. systems. The main points were as follows:

> The C.T.C. control equipment shall control the local signalling plants consisting of relay interlockings and automatic blocks of the railways' normal standard. The equipment shall be fully reliable but need not fulfil the rigorous safety requirements placed on the signalling plants. It shall be constructed of modern telecommunications material of good quality. Rotary switches should not be used.
>
> Information between C.T.C. office and field locations shall be transmitted on a single pair of wires by means of d.c. pulses of different polarity.
>
> The speed of transmission shall be sufficiently high to limit the quantity of transmitted information to a level such that delays in transmission are negligible.

Electronic components were not considered sufficiently reliable to justify their recommendation. This is the reason for recommending d.c. pulsing, which, in itself, has certain limitations when it comes to transmission over long distances.

The committee completed its work in 1957 by summarizing the experiences gained from C.T.C. installations in Sweden, Norway, Denmark and Finland. There had hardly been time for any new features to appear as regards the technical design of C.T.C. equipment. But there was ample evidence that the introduction of C.T.C. should be combined with modernization measures within other branches of railway operation.

Trial Installation Ånge—Bräcke, 31 kilometres

The traffic situation on the Ånge–Bräcke section of the main Stockholm–Boden line had become so desperate as to necessitate the immediate building, at a cost of 15 million kronor, of an additional track, which, to be sure, had long been foreseen. The alternative was to provide new sidings and introduce C.T.C. This would involve only a tenth of the cost of an additional track and could also be done fairly quickly. The economic gain afforded by C.T.C. was expected to be very considerable, since the four stations on the line could be left fully unattended, there being no local traffic duties. Consequently it would also be unnecessary to build residential quarters at the new sidings. It was considered that C.T.C. would provide the visual survey required to permit an efficient flow of traffic on the heavily loaded single track. The section was likewise judged to be sufficiently large for a trial installation, which would provide the necessary experience for subsequent larger installations. It was therefore decided to introduce C.T.C. on the Ånge–Bräcke line, in combination with new sidings, as soon as possible. A plant designed to the specifications of the Swedish, Norwegian, Danish and Finnish Railway Associations was ordered from L M Ericsson and opened on June 10, 1955.

The Ånge-Bräcke installation had certain characteristic features which have been retained in later Swedish Railways installations. It had keyboard operation, for example, and its system of control numbers has been employed elsewhere practically unchanged. The number of indications normally presented on the track diagram had been cut to a minimum. This was achieved by using a Total Indication Panel on which indications which are of interest only on special occasions are presented for one station at a time. These indications are sent from a field location only in response to a special control and normally,

therefore, do not load the transmission system. This arrangement has also been retained virtually unchanged in later installations.

In L M Ericsson's C.T.C. control equipment, the selection of station and control was effected with 4×6 pulses, which gave a number capacity of 36 stations with 36 controls per station. The indication system was designed for scanning of 49 indications per station, in groups of seven. To comply with the committee's recommendations, the station and control selection was modified to a pulse code system without redundancy. Using five pulses for station selection and six for control selection, this resulted in a number capacity of $2^5 = 32$ stations with $2^6 = 64$ controls per station. In the indication system, corresponding arrangements were introduced for station identification, while the earlier scanning system was retained for the actual indications. The capacity of the installation was thus raised to 64 controls and 49 indications per station. Each control, however, requires at least one indication transmission; and furthermore certain information must be transmitted without relation to control transmission, for example the indications which show the locations of trains. The proportion between controls and indications per station was therefore unsatisfactory and in later plants the indication system has been modified to provide $2 \times 49 = 98$ indications per station.

The design of the local signalling plants involved no great difficulty. The four siding stations had only two tracks, and no provision for shunting, except to remove faulty cars, appeared to be necessary. To facilitate the C.T.C. operator's work and increase the rapidity of movement of meeting trains, the principle of storage of routing controls was introduced to an extent which allowed all controls required for a meeting at a station to be sent in advance. The storage function was placed in the local interlocking plant, which had the advantage that the control section of the C.T.C. system need not provide for individual variations. This arrangement proved effective and has been retained in later installations.

Precise instructions for the despatch of trains with full safety have long existed in the Swedish Railways Safety Regulations. The introduction of C.T.C. necessitated extensive additions to these regulations. As already mentioned, the basic idea in the engineering of the C.T.C. system was that the safety functions should lie in the local interlockings, which should incorporate all safety functions which previously had rested on the stationmasters. The trains would therefore have to be protected by automatic means, which meant that all tracks must have track circuits. This actually resulted in a higher degree of safety than is possible under a verbal system of train control. The double control of meets, normally resting on the train crews, could thus be eliminated, including the laborious system of written notifications to train crews concerning changes of meeting stations. With a complete control of tracks by means of track circuits, there is in principle no need for a fixed timetable, since C.T.C. gives the operator the necessary survey of train movements. But, for the safety of trackmen, the present rule is that trains shall not run more than 5 minutes ahead of scheduled time. It is to be hoped that better methods will be found for informing trackmen of changes in train times so as to allow the C.T.C. operator greater freedom in directing train movements on an optimum basis.

It is normally part of the duties of a stationmaster to make sure that a train entering a station has stopped before he allows an opposing train to run in. There are, unfortunately, occasional instances when the train cannot be brought to a stop until a few yards beyond the exit signal, which means that the locomotive may obstruct the meeting train. After thorough discussion it was decided that the home signal for a meeting train should not be cleared until the crew of

Fig. 2 X 2605

In northern Sweden the points are electrically heated to ensure their functioning in cold weather

the first arrival has confirmed that the train has stopped by pressing a button at the exit signal. This was considered to be a cheaper and sufficiently reliable alternative to the provision of protective points at the ends of the tracks. Since, so far as is known, no other railway has adopted similar arrangements, the precaution is presumably exaggerated; but once these buttons had been introduced, it proved difficult to do without them.

With the chosen form of control system and track diagram, the equipment was so small that it could be accommodated in the existing stationmaster's office at Ånge. The relay racks were placed in the basement below.

The experience of this trial installation has been generally satisfactory. The primary aim of increasing the capacity of the line without adding an extra track or manning the siding stations has been accomplished. The traffic side has admittedly not wished entirely to write off the plans for double tracks, but the Ånge–Bräcke line has been moved to the bottom of the list of urgent reconstruction jobs.

As might be expected in a trial installation, various disturbances were encountered during the first year. One of the lessons learnt was that the maintenance requirements for the local signalling plant must be placed very much higher than had been customary earlier, when there were station staff available to deal with a fault. For the same reason standby power had to be provided. Electric heating of points (fig. 2) had been foreseen from the outset.

High requirements had to be placed on the telephone system which links the line signals with the C.T.C. office. The telephones are a very important feature when a disturbance occurs in the C.T.C. system and should preferably operate independently of it.

The traffic regulations provide for the movement of trains without undue delay in the event of isolated signal faults, without need for manning the stations. In principle, stations need be manned only on the occurrence of overall faults of long duration in the C.T.C. system. This has happened only on rare occasions on the Ånge–Bräcke line, two of which were due to damage, during work on the track, of the cable used for C.T.C. transmission.

Kiruna—Björnfjell, 127 kilometres

Simultaneously with the C.T.C. trials on the Ånge–Bräcke line, the signal installations on the northern section of the Ore Line[1] were being extended, primarily in order to equip it with automatic blocks and relay interlockings. The decision to introduce block signalling on this line was initially due entirely to safety considerations since, by Swedish Railways standards, it is an unusually heavily trafficked single-track line. The division of the station-to-station sections into block sections at the same time yielded a slightly higher carrying capacity. This line as well has little local traffic, and there seemed to be good propects of saving manpower at siding stations through the introduction of C.T.C. In view of the satisfactory experience also from the Ånge–Bräcke line, is was decided to install C.T.C. control equipment for the control of the line Kiruna–Björnfjell (Björnfjell lies on the Norwegian side of the frontier). The equipment was delivered in the spring of 1958 and brought into service on June 1 of the same year.

[1] The Ore Line is the popular name for the line in northernmost Sweden from Luleå to Riksgränsen on the Norwegian frontier, used mostly for the carriage of iron ore.

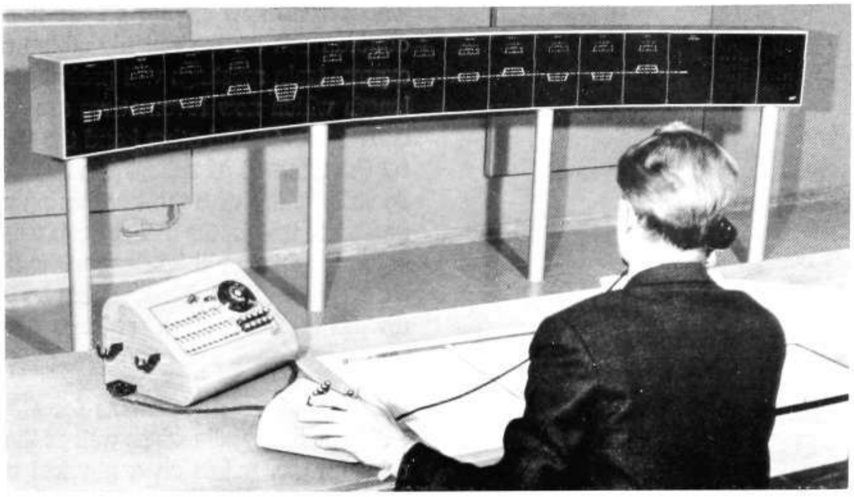


Fig. 3 X 8227

Original C.T.C. office in Kiruna for control of line Kiruna (Sweden)—Björnfjell (Norway)

The system has since been extended southwards to Gällivare and controls now altogether 22 stations over a distance of 229 km

The C.T.C. line is about 130 km in length and has 13 siding stations, of which 12 are at present[1] under remote control. The C.T.C. office is at Kiruna, being housed in a new building which also contains a modern interlocking plant for the Kiruna Ore Yard, the departure station for the ore trains. The system has functioned so reliably that, at stations without local traffic duties, all staff have been withdrawn with the exception of, generally, one man at every third station. The disturbances which occur are chiefly in the local signalling plants, particularly in the parts which are connected to the track. The close headway and the severe climate during a large part of the year have made it very difficult to keep the track in the best condition. Two total breakdowns have occurred in the C.T.C. system, both due to damage of the telephone cable during track maintenance.

Fig. 4 X 2595 X 9151

The map shows the Swedish Railways C.T.C. plants already installed or scheduled for installation, all of which have been or are to be delivered by L M Ericsson

■ C.T.C. office

❚❚❚❚❚ C.T.C. line

New tonnagemile records for the line have been established on several occasions during the past years, the latest being in April 1961. They are attributable largely to the provision of longer sidings and better rolling stock, but the C.T.C. system has undoubtedly been an important factor. So long as no trouble occurs and the nominal timetable can be followed, C.T.C. does not in itself increase the capacity. But dislocations, due for example to locomotive damage, are inevitable. When the line capacity is fully utilized, a primary disturbance may result in a total stoppage of traffic. In practice, therefore, gaps must be allowed in the timetable to give time to deal with disturbances. C.T.C. assists in limiting the secondary disturbances and, in practice therefore, does increase the capacity by reducing the need for gaps in the timetable.

Ljusdal—Mellansel, 358 kilometres

The Ljusdal–Mellansel section (fig. 4) is a critical part, from the point of view of train movements, of the long single-track line from Krylbo to Boden, the main north Swedish line. In the middle of the section lies Ånge, a main junction for goods traffic. It has hitherto had 35 stations at fairly irregular intervals of between 7 and 14 km. The maximum speed is still 90 km/hour, which means that the line is heavily burdened despite the fairly moderate number of trains—about 50 trains a day south and 40 north of Ånge. Some stations are in out-of-the-way places and, moreover, have poor staff dwellings. It is difficult to staff the stations and they are often left unattended during a large part of the 24 hours, to the detriment of operation, especially when dislocations occur. Since the main line to Boden is one of the lines on which there is the greatest prospect of an increase in traffic, it has long been plain that something must be done to step up its capacity. Following the successes on the Ånge–Bräcke section, it was decided to adopt a combination of C.T.C.

[1] Since the time of writing, the system has been extended southwards to Gällivare and now comprises 22 stations over a distance of 229 km.

with certain new sidings on the longest stretches between stations, and with double track on the roughly 60-km stretch south of Ånge, where most of the express train meetings will probably take place. To permit goods trains of the length which new locomotives are able to pull, all sidings were prolonged to 650 metres. On the other hand the track system at many stations was simplified by the removal of sidings used for traffic which has now been discontinued. In conjunction with the lengthening of sidings, and when justified by the local passenger traffic, the main routes were moved away from the station buildings, wherever this could be done without undue cost, in order to reduce the risks of personal injury from passing trains. Station intervals of above 8 km were divided into two block sections.

In the choice of locations for C.T.C. offices, it was necessary to consider the technical conditions as well as the traffic demands. Since the C.T.C. system employs d.c. pulses on a physical circuit, its range is limited unless special equipment is added. The limit lies at 5,000 ohms' resistance and a capacitance of 8 μF. Wire pairs with 1.3-mm conductors were available, and an office without special auxiliary equipment could control a distance of about 200 km in each direction. Since the office should obviously be located in Ånge on traffic grounds, it was logical that the Ånge office should control the Ljusdal–Långsele section of line. Långsele is an important junction and, moreover, lies on the boundary between different traffic sections. It was therefore natural to place a second C.T.C. office in Mellansel with the idea of subsequently controlling from it a corresponding length of line northwards. Later, however, it proved better to make the C.T.C. areas larger than had been initially planned, and it was therefore decided to place the office for the Långsele–Mellansel section at Vännäs for subsequent control of the entire line from Långsele to Jörn.

As already mentioned, the length of line which can be *directly* controlled from a C.T.C. office—that is a C.T.C. section—is limited. It is actually limited by three factors, each of which under different circumstances may be the decisive one. With large distances between stations and sparse traffic, the limit is set by the resistance. If there are many stations but sparse traffic, the critical factor may be the station number capacity, which is limited to 32 stations; but this is very seldom the case. And thirdly, with dense traffic, the congestion on the line is the decisive factor. The Kiruna–Björnfjell line has been made into a single section without any troublesome congestion occurring, and it should therefore have been possible to form single sections of the Ljusdal–Ånge and Ånge–Långsele stretches. But, in the latter case, since the traffic was heavier and, moreover, faster and more irregular, it was decided to divide each stretch into two sections. In the event of a total breakdown due to failure of a transmission equipment, the disturbance will then be more limited. Moreover, since the transmission equipments in the C.T.C. office can to some extent act as standby for one another, the main rise of cost will be in the physical circuit from the C.T.C. office to the beginning of the more remote sections.

If it is found desirable to have large C.T.C. areas, a limit will soon be reached at which the resistance condition cannot be fulfilled for the most remote sections, even if phantom or superphantom circuits are used up to the section boundary. For this reason conversion equipment has been designed so as to permit the use of two two-way telegraph circuits for that link.

Work on the local interlockings for the C.T.C. plant was started in 1957. The pace of this work had to be adjusted to the very considerable work on track reconstruction, the extent of which may be appreciated from the fact that, on the Ljusdal–Långsele section, track reconstruction has cost 52 million kronor, while the signalling plants including the C.T.C. system cost only

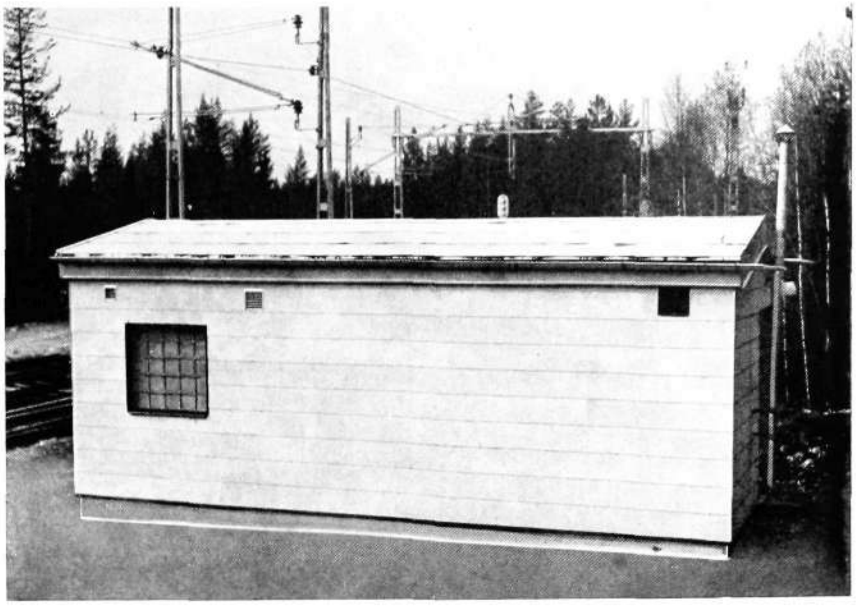


Fig. 5 X 8291

Relay buildings of lightweight concrete have replaced the old station buildings

11 million. The work has therefore proceeded fairly slowly and it was not until January 30, 1961, that the Alby–Bispgården section, 135 km, could be completed. The Bispgården–Mellansel section is expected to be in service by the year end 1961.

Various station buildings on the line are in poor condition and need extensive repairs. They are also too large for their new functions. They are generally timber structures. In many cases, therefore, it was questionable whether they should be retained, since the stations might be unattended. The local relay equipments and local control panels have in most cases, therefore, been placed in small lightweight concrete buildings of standard design (fig. 5). This has had the advantage that locomotive crews and other persons who may have to employ the local control panel (fig. 6) can find it immediately. The control panels are also clearly marked with explanatory text to facilitate their use by unaccustomed persons.

After some reconstruction of the Ånge station building, an acceptable, even if not ideal, control room was formed (fig. 1).

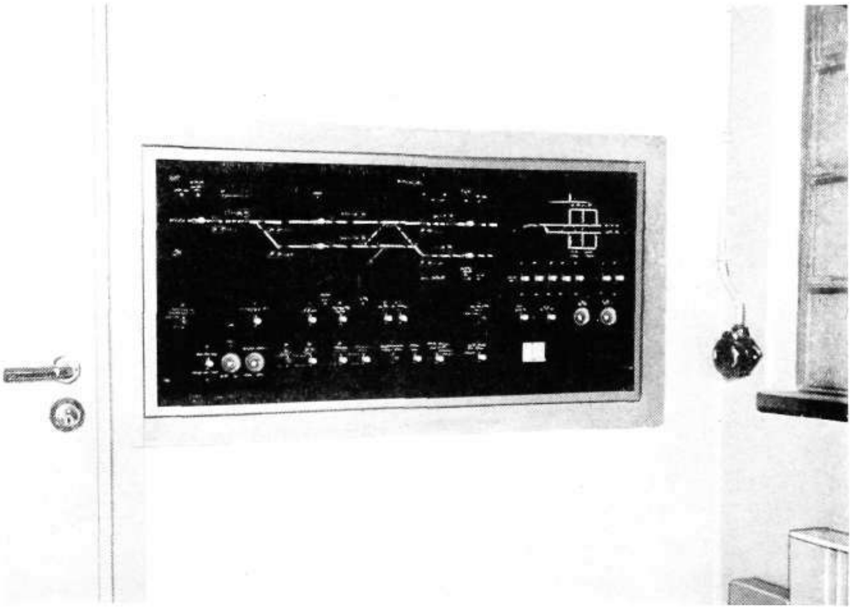


Fig. 6 X 8292

Each station relay building is divided into two compartments. On the dividing wall is a control and indication panel from which the station's signal system can be locally operated when necessary. The other room contains the interlocking and remote control relays.

At Vännäs a building is being constructed which will contain accommodation particularly designed as a C.T.C. office to control the Långsele–Jörn section, with spare accommodation for later control of secondary lines.

The track diagram and the keyboard control system have been described in Ericsson Review No. 2, 1958. The operator's work is facilitated by the provision of traingraphs, two in the Ange office and provisionally one at Vännäs. The traingraphs are placed on separate control desks (fig. 1). It is calculated that, when fully extended, the Ange office will have three operators during heavy traffic periods, two of whom will have keyboards, controlling one half of the installation each, while the third will act as assistant, keeping notes and making telephone calls. The office is designed to permit operation from a single position during light traffic periods. Experience has shown that most of the operators' time is taken up, not on directing train movements, but on fitting in track maintenance between train movements and arranging for transport of the track gangs.

Contact between locomotive drivers and C.T.C. office is established on a selective calling telephone system designed for secrecy of conversation and compulsory check-back to preclude any possibility of mistakes in the issue of orders. There is a separate, non-secret selective calling telephone system for contact with track maintenance gangs.

The Swedish Railways expect that the planned reequipment of the line will give it an adequate capacity during the foreseeable future. C.T.C. will allow the re-equipped line to operate economically, since the traffic staff will be cut by about 70 men.

Future Plans

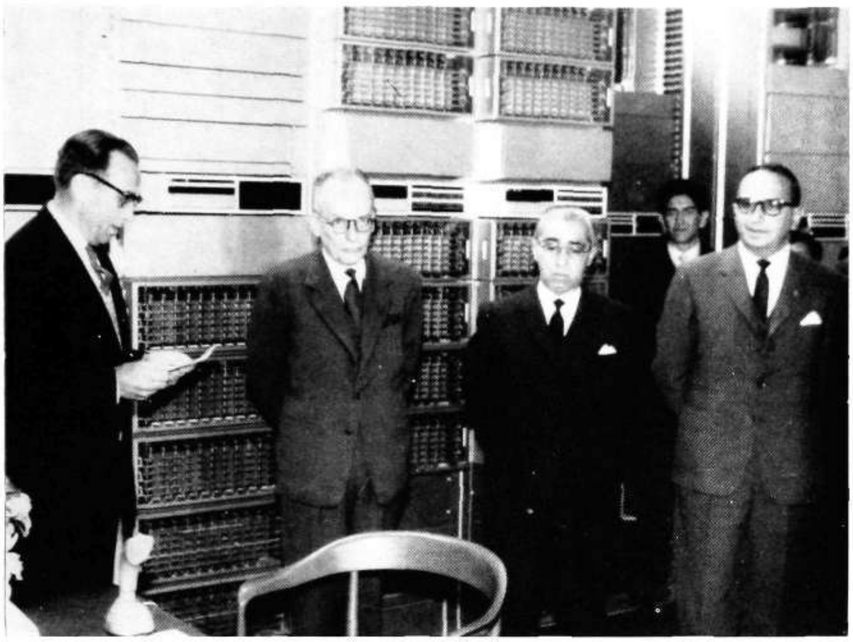
The manpower saving attendant on C.T.C. is so great on lines of the average Swedish Railways type that it covers the costs not only of the C.T.C. equipment itself, but also of a large part of the local signalling plant. Since the latter will in any case have to be modernized sooner or later and brought up to a standard consistent with the day's demands for traffic safety, and since C.T.C. leads to improved railway operation, C.T.C. should prove a profitable investment on practically all lines which will be retained in operation in future. Further thought must still be given to the question of which are the most important projects. In order to be able to make long-term plans for the extension of station yards and the provision of signal towers, the Swedish Railways are at present preparing a plan of the areas which would be suited for C.T.C. if C.T.C. were to be introduced within the major part of the railway network which is expected to be still operating around 1980. Thereafter it is planned that a continuous flow of C.T.C. installations shall be built at a rate consistent with the Railways' financial and personnel resources.

The Kiruna–Gällivare section is to be commissioned in September 1961, and work is in progress on the Gällivare–Boden section. Next on the list is the West Coast line.

If so extensive a programme is to be successfully accomplished, particular attention must be paid to the reliability of the technical arrangements. Arrangements for limiting the consequences of technical faults will presumably have to be introduced on a hitherto unprecedented scale. Consideration must be given, for example, to the need for connecting either end of a section to the C.T.C. office over any length of circuit so as to permit the use of alternative circuits in the event of cable failure. The use of static components in the transmitting equipments should now be feasible, moreover, with a view to increasing their life and reliability with only moderate maintenance.

The large quantity of apparatus will make maintenance an important economic factor. Advances in the component field, however, suggest that future equipments will need less supervision than those of today and that it should be possible to maintain them in good condition with a moderate maintenance force.

NEWS *from* *All Quarters of the World*



100,000 Ericsson Lines in Bogotá

The 3,000-line El Chicó exchange in Bogotá, Colombia, was ceremoniously opened on July 4. With this exchange, which is equipped with Ericsson crossbar switches, Bogotá has reached the 100,000-line mark, which makes it fourth telephone city among South American capitals.

The new exchange forms part of the system owned and operated by Empresa de Teléfonos de Bogotá. It was opened by the President of Colombia, Alberto Lleras, in the presence of the Mayor of Bogotá, Juan Pablo Llinás, and a large number of representatives of industry and commerce and of state and municipal authorities.

After the blessing pronounced by Monseigneur Ernesto Solano, the director of the company, Luis Eduardo Páez, spoke of the company's development since its start. The importance of the day's solemnities was not simply the passing of the 100,000-line mark in Bogotá. It was also the 20th anniversary of Empresa de Teléfonos de Bogotá as independent unit. With justified pride Sr. Páez stressed that the company had reached its present position by its own efforts without financial assistance from state or municipality, thanks to the foresight of its administration both in engineering and commercial matters.

President Lleras thereafter held a brief address, put through the first call, and the exchange was opened for traffic.

(Left) Mr. Olaf Gustafson of Cia Ericsson Ltda hands over the El Chicó exchange to the Mayor of Bogotá. Apart from Mr. Gustafson are seen (from left) President Alberto Lleras, Mayor Juan Pablo Llinás and Sr. Luis Eduardo Páez.

One of Ericsson's Largest P.A.B.X. to Italy Next Year

L M Ericsson's French associates, Société des Téléphones Ericsson, STE, have received an order for one of the largest P.A.B.X. ever manufactured within the Ericsson group. This unit, the manual desk of which is seen in the photograph below, is to be delivered to Istituto Nazionale Previdenza Sociale (National Insurance Office) in Rome. It will be equipped with 2,800 extension lines (ultimate capacity 3,200), 215 exchange lines (240), and 10 manual positions, of which 5 for blind operators. It will be manufactured in the Colombes factory to STE's crossbar switching system CP 400, of which several units have already been delivered to countries outside France, including Finland and Holland. The delivery will start with 400 lines in November this year and be completed by November next year.

Further Railroad Automation in Denmark

Ericsson Delivers Automatic Control Equipment

The Danish Railways, DSB—as a step in the modernization of its railroad operation—are now installing equipment in the C.T.C. office at Odense for automatic control of the C.T.C. plant on the double-track Nyborg–Fredericia line, extending over nearly 60 miles with 15 stations.

The C.T.C. operator gives every train on the line a two-digit destination number, which he does by pressing two buttons on a miniature track diagram. The number is shown on the C.T.C. panel opposite the train position lamp and automatically follows the train across the panel. The number successively and automatically causes the necessary controls to be sent to the stations, so that the C.T.C. operator need take no further action until the train has arrived on the destination track at the destination station.

Mr. W. Wessel Hansen, Chief Signalling and Telecommunications Engineer of DSB, recently demonstrated the "destination indication system" to the President of DSB, Mr. P. E. N. Skov, and some of his colleagues.

L M Ericsson, which has previously delivered the C.T.C. equipment for the Odense plant, is also the supplier of the destination indication system, which is based on crossbar switching.

Mr. W. Wessel Hansen (right in the photo above) demonstrates the destination indication system to (from left) Messrs. J. A. Hansen, District Engineer, P. E. N. Skov, President, G. O. Randrup, Traffic Inspector of Danish Railways, F. Loell, Chief Engineer of Dansk Signal Industri A/S, E. Vibjerg Petersen, Signal Engineer, and G. Larsen, Chief Traffic Assistant, of Danish Railways.

Maintenance Conference with Delegates from Twelve Countries

This year's Maintenance Conference, with 38 representatives of telephone administrations in twelve European, African and Asian countries, was held at Ericsson's head office at Midsommarkransen, Stockholm, from May 29 to June 2 (see photos below). It was attended by eleven delegates from L M Ericsson and four from the Swedish Administration.

The programme comprised maintenance of exchange equipment, outside plant and transmission equipment. In distinction to previous conferences, the papers had been circulated to delegates in advance. At the conference the speakers presented resumés of their papers, which were then followed by discussion.

To make the discussions as fruitful as possible, questions were addressed to a panel consisting of the speaker and of two or three experts on the particular subject. The general opinion was that this arrangement proved very successful.

During the week of the conference, visits were paid to the main factory workshops, to the Long Distance Division Laboratory, and to Swedish Administration plants in Stockholm.

In the week June 5–9 some thirty of the delegates made a trip to Gothenburg and Denmark. In Denmark visits were paid to the administrations of Jutland, Fyn and Copenhagen, and in Gothenburg to plants of the Swedish Administration.

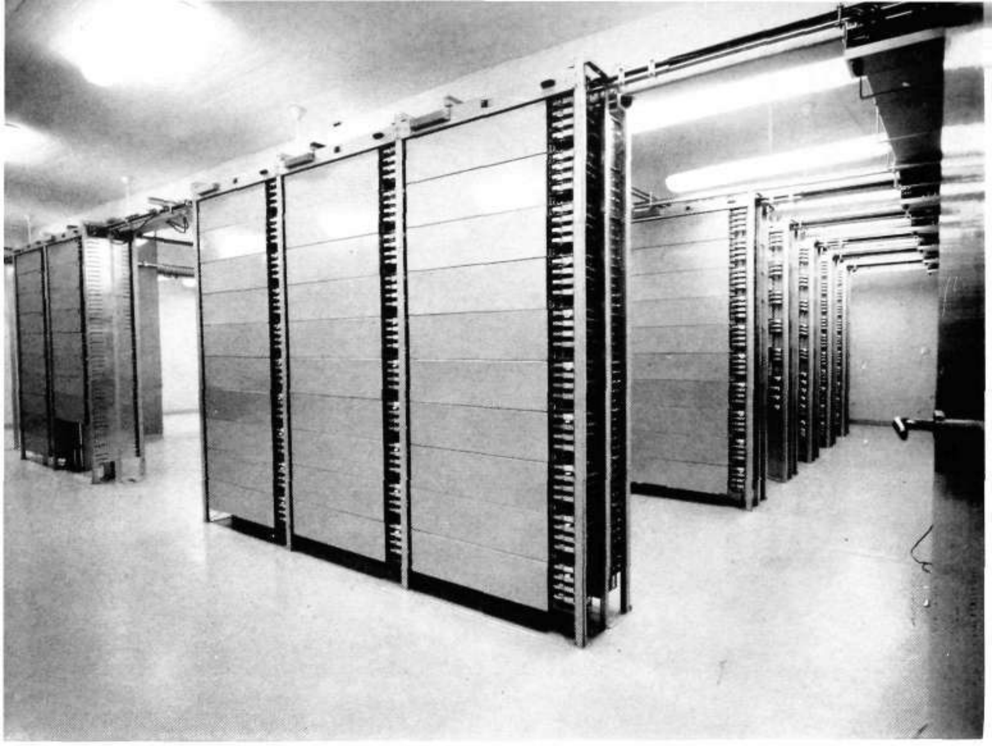
A delegation from the Australian Post Office visited the Ericsson head factory in early June. In the photo (right) Mr. C. Sawkins and Mr. I. Kline, in centre, are being shown round the plant by Mr. Malte Patricks, right, and Mr. Eric Lundqvist.

Mr. A. G. Senapathy, director of the telecommunications engineering firm of A. G. Senapathy & Co., Bangalore, India, on a visit to the Ericsson head factory (below).

Recent visitors to the Ericsson head factory were a group from Association des Elèves-Ingénieurs de l'Ecole Spéciale de Mécanique et d'Electricité (below). This was one of a series of visits to L M Ericsson during the year from French engineering colleges.

AB Rifa's CR units have aroused keen interest on export markets and have been widely sold in U.S.A. In the photo above, Rifa's representative, Mr. Maurice D. Teichner (right) of Santa Monica, California, with sales manager of Rifa, Mr. P. O. Nyhult, are studying the moulding of CR units, being done by Mrs. Irene Lindås.

Stockholm had a visit recently from the Dutch navy, during which a group of officers were shown over the Ericsson head factory. In the photo (left) Mr. Rudolf Plekker is demonstrating the Ericovox. (Sitting from left) O. den Boeft, A. M. Nuyten, A. van Eden; (standing from left) F. J. M. van Oudenhoven, E. D. G. Gallas, A. G. van Rinkhuyzen, C. Fock and C. P. von Weiler.



The crossbar switchboard delivered by L M Ericsson to ASEA's new offices is the largest P.A.X. in Sweden.

Largest P.A.X. in Sweden an L M Ericsson Product

The largest P.A.X. in Sweden was put into service some time ago at ASEA's new offices in Västerås. Supplied by L M Ericsson, it is of crossbar type ARD with a capacity of 4,000 lines. The extension instruments consist of keyset and dial telephones, Ericofons and Ericovoxes.

The new ASEA office, 370 ft. long, with 10 storeys above ground and 3 below, and a floor area of 355,000 sq.ft., is one of Sweden's largest office buildings.

The P.A.X. as originally delivered had 3,500 lines, but was brought up to its present capacity in February this year. The previous system, a 3,000-line branch exchange, will in future be used for external traffic alone.

In order to be able to make efficient use of the rapidity of the crossbar switches, a couple of hundred of the extension instruments have been fitted with keysets. On every call to a 3-digit number from a keyset telephone, 4 seconds of time are saved compared with a dial telephone.

With the previous P.A.B.X. it took 0.7 sec. to get dial tone, and after dialling the last digit 1.8 sec. before the signal reached the called party. The new P.A.X. returns dial tone within 0.25 sec., before the user even has time to bring the receiver to his ear, and the same time to produce the first signal after dialling of the last digit.

The chief significance of the rapid functioning of the ARD unit, however, is that the switching equipment is employed only during a very short period on each call. The P.A.X. can therefore handle a considerably larger number of calls per unit of time than can a P.A.X. with mechanical switches.

Another finesse is that connecting circuits are not occupied during the setting-up of calls. Only when the P.A.X. has received particulars of the wanted number and checked that the extension is disengaged is a connecting circuit seized. This avoids unnecessary occupation of connecting circuits, with the attendant congestion during rush hours.

In due course the P.A.X. is to have various supplementary services added, in the first place call-back, interception, remote dictation and telephone answerer facilities.

New Appointments

Mr. Holger Ohlin, having attained pensionable age, will retire on July 1, 1961, from his appointments as Executive Vice President and Chief Financial Officer of the Ericsson Group, but will remain available for consultation on special questions.

The Board has made the following appointments as from July 1, 1961:

Vice President, Finance: Gunnar Svalling

Vice President, Auditing: Bertil Pehrsson

Vice Presidents of the Parent Company: Erik Lindström and Björn Lundvall

Chief Engineers: Anton Diesen, Folke Ek, Sten Engström, Erik Eriksen and Fred Sundkvist.

Erik Skoog has been appointed Chief of the Treasury Department of the Parent Company.

L M Ericsson telephones, and particularly the Ericofon, occupied a prominent position at an exhibition arranged by the Helsinki Telephone Company, Finland (below).

UDC 656.25
LME 86

LUNDGREN, S: *Longest C.T.C. Line in Europe.* Ericsson Rev. *38*(1961): 3, pp. 79—86.

C.T.C. has become an acknowledged and increasingly employed means of modernization of operations on the Swedish State Railways, which in January 1961 opened the first section of what will be the longest C.T.C. line in Europe, between Ljusdal and Mellansel on the main route between Stockholm and Boden. This article gives an account of the technical principles which the Swedish, Norwegian, Danish and Finnish Railways have considered necessary for operation of C.T.C. plants and describes, firstly, two important C.T.C. plants installed prior to the Ljusdal–Mellansel system, followed by a fuller description of the latter installation. Some account of the future plans of the Swedish Railways is also given. The technical aspects of the C.T.C. system have been described in earlier articles in Ericsson Review (No. 4, 1954, No. 2, 1958, and No. 3, 1960).

UDC 621.39(100)
621.39.004.5
LME 808, 154

ERICSSON, E A: *Supervision and Maintenance Problems in a Worldwide Telecommunication Machine.* Ericsson Rev. *38*(1961): 3, pp. 60—68.

This article outlines some problems of supervision and maintenance of a worldwide automatic telecommunication machine. None of the problems are new, as they already exist in national switching, but they will be more intricate and more difficult to handle on a worldwide basis. Some suggestions are given for integrated controlled corrective maintenance and the training of supervision and maintenance personnel, as well as the public, in order to attain the desired efficiency in the switching machine.

UDC 621.373.44
LME 7559, 1528

LARSSON, B & SVENSSON, Å: *Pulse Generator for Testing Switches and Relays.* Ericsson Rev. *38*(1961): 3, pp. 69—75.

For the testing of switches and relays and of automatic telephone exchange equipments containing switches and relays, a device is needed which can close and open circuits a given number of times at a given frequency and with a given make-break ratio. To meet this requirement, Telefonaktiebolaget L M Ericsson has developed the pulse generator ZYH 20201 presented in this article.

UDC 621.395.22
LME 8371

EKSTRÖM, H & TRÄGÅRDH, A: *Intercom System for Hotels and Motels.* Ericsson Rev. *38*(1961): 3, pp. 76—78.

With the growth of travel, and in particular motoring, new hotels and motels are springing up everywhere. Especially the small ones wish for a cheap and simple system of intercommunication between residents and reception office. L M Ericsson has designed a system which, through its rapidity, capacity and other operational properties, fulfils the needs of small hotels and motels. The system is also well suited for schools and factories with similar requirements.

The Ericsson Group

Associated and co-operating enterprises

• EUROPE •

Denmark

L M Ericsson A/S *København F*, Finsensvej 78, tel: Fa 6868, tgm: ericsson

Telefon Fabrik Automatic A/S *København K*, Amaliegade 7, tel: C 5188, tgm: automatic

Dansk Signal Industri A/S *København F*, Finsensvej 78, tel: Fa 6767, tgm: signaler

Finland

O/Y L M Ericsson A/B *Helsinki*, Fabianinkatu 6, tel: A8282, tgm: ericssons

France

Société des Téléphones Ericsson *Colombes (Seine)*, Boulevard de la Finlande, tel: CHA 35-00, tgm: ericsson

Paris 17e, 147 Rue de Courcelles, tel: Carnot 95-30, tgm: eric

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Swedish Ericsson Company Ltd. *London, W. C. 1*, 329 High Holborn, tel: Holborn 1092, tgm: teleric

Production Control (Ericsson) Ltd. *London, W. C. 1*, 329 High Holborn, tel: Holborn 1092, tgm: productrol holb

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Setemer, Soc. per Az. *Roma*, Via G. Paisiello 43, tel: 868.854, 868.855 tgm: setemer

SIELTE, Soc. per Az. *Roma*, C. P. 4024 Appio, tel: 780221, tgm: sielte

F. A. T. M. E. Soc. per Az. *Roma*, C.P. 4025 Appio, tel: 780021, tgm: fatme

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den Haag—Scheveningen, 10, Palacestraat, tel: 55 55 00, tgm: erictel-haag

Norway

A/S Elektrisk Bureau *Oslo NV*, P.B. 5055, tel: Centralbord 46 18 20, tgm: elektriken

A/S Industrikontroll *Oslo*, Teatergaten 12, tel: Centralbord335085, tgm: indtroll

A/S Norsk Kabelfabrik *Drammen*, P. B. 205, tel: 1285, tgm: kabel

A/S Norsk Signalindustri *Oslo*, P. B. Mj 2214, tel: Centralbord 56 53 54, tgm: signalindustri

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Spain

Cía Española Ericsson, S. A. *Madrid 4*, Conde de Xiquena 13, tel: 31 53 03, tgm: ericsson

Sweden

Telefonaktiebolaget L M Ericsson *Stockholm 32*, tel: 19 00 00, tgm: telefonbolaget

AB Alpha *Sundbyberg*, tel: 282600, tgm: aktiealpha-stockholm

AB Ermex *Solna*, tel: 82 01 00, tgm: elock-stockholm

AB Ermi *Bromma 11*, tel: 262600, tgm: ermibolag-stockholm

AB Rifa *Bromma 11*, tel: 26 26 10, tgm: elrifa-stockholm

AB Svenska Elektronrör *Stockholm 20*, tel: 44 03 05, tgm: electronics

L M Ericssons Driftkontrollaktiebolag *Solna*, tel: 27 27 25, tgm: powers-stockholm

L M Ericssons Signalaktiebolag *Stockholm Sv*, tel: 68 07 00, tgm: signalbolaget

L M Ericssons Svenska Försäljningsaktiebolag *Stockholm 1*, Box 877, tel: 22 31 00, tgm: ellem

Mexikanska Telefonaktiebolaget Ericsson *Stockholm 32*, tel: 190000, tgm: mexikan

Sieverts Kabelverk AB *Sundbyberg*, tel: 282860, tgm: sieverts-fabrik-stockholm

Svenska Radioaktiebolaget *Stockholm 12*, Alströmergatan 14, tel: 22 31 40, tgm: svenskradio

AB Östmarks Låsfabrik *Eskilstuna*, Munktellsgatan 5, tel: 31455

Switzerland

Ericsson Telephone Sales Corp. AB, Stockholm, Zweigniederlassung Zürich *Zürich*, Postfach Zürich 32, tel: 325184, tgm: telericsson

West Germany

Ericsson Verkaufsgesellschaft m. b. H. *Düsseldorf 1*, Worringer Strasse 109, tel: 84 461, tgm: erictel

• ASIA •

Burma

Telefonaktiebolaget L M Ericsson *Rangoon*, P.O.B. 1008, tgm: ericsson

India

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Extension of Telephone Plant with Regard to the Value of Subscribers' Time

Y RAPP, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

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A paper in Ericsson Technics No. 1, 1961, entitled Extension of Telephone Plant with Regard to the Value of Subscribers' Time, dealt with the question of accessibility and intelligibility on telephone circuits from the aspect of the inconvenience experienced by subscribers, evaluated in monetary terms, as a result of insufficiency in either of these respects. This evaluation is made by estimating the time lost by subscribers owing to congestion of switches and to unsatisfactory transmission on the circuits and by ascribing a value to the time so lost. From this starting point the number of switches on the traffic routes and the diameter of conductors in subscribers' cables can be determined so that the sum of the plant cost and of the economic value of the inconvenience to subscribers is as small as possible. The present article explains some of the basic principles involved in the paper in Ericsson Technics.

A subscriber bases his opinion on the quality of a telephone circuit largely on his observations of the time required to obtain connection and of the extent to which he can make himself understood. It is therefore a matter of prime importance for a telephone administration to provide for the subscribers' requirements of accessibility and intelligibility as economically as possible.

In a telephone plant savings can be made by limiting the number of switches and trunk cables. But this results in high congestion, which causes inconvenience to the subscribers.

Savings can also be made by reducing the diameter of conductors in the cables. But this results in reduced intelligibility of communication, which may give rise to misunderstandings and repeated questioning, likewise with inconvenience to the subscribers.

On the other hand investments in telephone exchanges and cable plant cannot be increased indefinitely, so as to guarantee the quickest possible establishment of connections and perfect intelligibility under all circumstances, for the cost of the calls would then exceed their usefulness to the subscriber and the value he ascribes to them.

Therefore, when deciding on the amount of money to spend on telephone plant to satisfy the subscribers' demands in respect of accessibility of switching paths and intelligibility of conversation, one should consider, on the one hand, the cost of the plant and, on the other, the cost and the risk to subscribers through the inconveniences which must necessarily arise, and install the quantity of equipment which results in the lowest sum of the cost of the plant and of the economic value of the inconveniences to subscribers.

When should a Decision to Extend Plant be Made? And what Quantity of Plant should be Installed?

The need for telephones generally grows with time. Therefore, when deciding on the capacity for which the plant should be built, it is not sufficient to consider the immediate requirements alone; some thought must be given also to the future needs.

In all decisions relating to the matching of plant expansion to a growing need, the following questions must be answered:

When should decisions to extend the plant be made?

How large a capacity should the plant be planned for?

What method should be employed to satisfy the requirement?

In the sequel it will be assumed that the last question has been decided or can be decided by a number of alternative cost estimates. The decision function thus contains two essential factors, a *time factor* and a *quantity factor*. In other words, for every future extension of the plant a decision must be made as to when the preparations should start and what size of plant should be planned for.

Once a decision has been made, some time is required for completion of the plant, which may vary from a month or so in the case of switches in a telephone exchange to several years for the construction of new exchanges and cable plant. The two quantities describing the need–the number of *subscribers* and the quantity of *traffic*–can therefore not be decided exactly, but must be estimated by allotting to each increase in the need a given probability.

The question of the most suitable *size* of plant to be installed will depend predominantly on the magnitude of the future need and on the degree to which the costs per unit diminish with the number of units (lines, switches) which are installed at one time. In such case one is faced with the choice either of building the plant in large instalments at long intervals of time or in small instalments at short intervals. From the economic aspect the size of instalments should be such that the *present value* of the costs of future extensions may be anticipated to be as low as possible.

The *time* for instalment of a given quantity of equipment, and so the time when the decision to extend the plant should be made, will depend on the cost of the new plant and on the reduction in the intensity of inconveniences which may be anticipated as soon as the plant is brought into operation.

If the size of a plant extension must be decided simultaneously with the time of its installation, the problem–at least in principle–will be more complicated, since the increase of inconvenience with time depends on the capacity of the plant. The relations between growth of need, capacity of plant, inconveniences, and time of installation are shown in fig. 1.

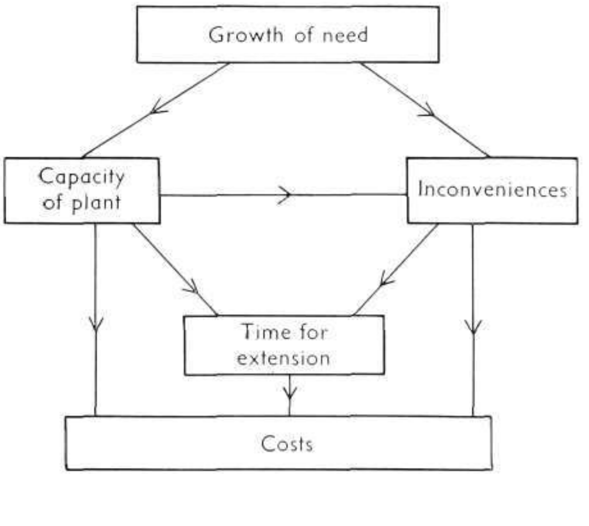

Fig. 1 X 8309

Schematic illustration of relations between growth of need, capacity of plant, inconveniences to subscribers, time for extension, and costs

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The question of the time when a plant should be extended becomes simple if we assume, for example, that a traffic route is to be extended by one or a given number of switches at a time. In such case one can initially disregard the time factor and determine the number of switches which will be required for different quantities of traffic. The procedure for this calculation is shown later. For the moment it is sufficient to assume that the calculation has been made and that we are in possession of a table showing the requirement of switches for different traffic quantities. We also possess a prognosis showing the probability of different growths in the need.

These data, together with a knowledge of the time of delivery of the equipments, are sufficient for determining the times at which decisions to extend the plant should be made. As time passes, the requisitioning plan can be improved upon as the growth in the need can be better foreseen.

Since, under conditions of growing need, and especially of growing traffic, the inconveniences to subscribers rise very quickly, it is at least as important to decide on extension at the correct time as it is to make the correct decision as to the size of the extension. In some cases one may even make a greater mistake in making a decision too late than in making a somewhat wrong decision concerning the capacity to be installed. The importance of the time factor in all decisions concerning plant extensions to provide for a constantly growing need, therefore, merits particular attention.

Principles for Calculating the Number of Switches on a Route

Calculations of the number of switches on traffic routes have hitherto been made largely on the basis of

1. the busy hour traffic,
2. an upper limit for the congestion during the busy hour.

If one wishes, instead, to determine the switch requirements on economic principles, so that the sum of the cost of the switches and of the economic value of the inconveniences to subscribers through congestion is a minimum, these criteria are no longer usable. One must, instead, base the calculation on

1. a frequency function which describes the traffic during a whole year,
2. the cost of a switch or group of switches,
3. the economic value of the inconveniences due to congestion.

The traffic on a route varies from hour to hour and from day to day during the year, and congestion conditions are not unusual at very different times of the day or year. For this reason the traffic cannot be well defined by a weighted mean value during a number of so-called "busy hours", but variations during the whole year must be taken into account. This can be done by describing the traffic by a statistical distribution which indicates the part of the total time, described by the frequency function, during which a traffic of given intensity prevails.

In determining the number of switches on economic principles, one cannot proceed from the congestion or from the corresponding traffic losses. In actual fact these quantities are the product of calculations based on the switch cost and on the value of the subscribers' time.

In order that the sum of the switch cost and of the value of inconveniences to subscribers may be as small as possible, obviously the number of switches must be determined so that an increase or decrease of one switch unit results in an increase of the sum.

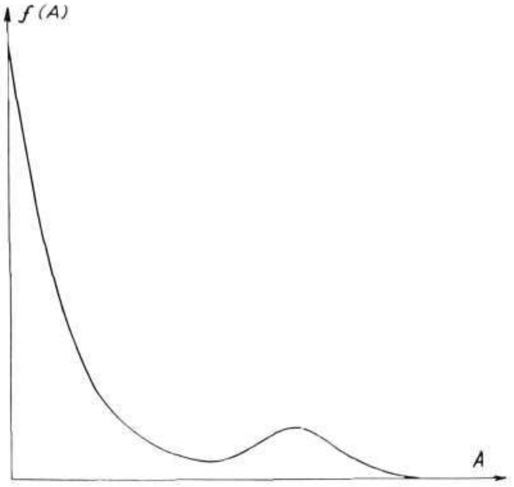

Fig. 2
Frequency function for the traffic

X 2600

To determine this number one proceeds as follows.

The frequency function for the traffic, which may have the appearance shown in fig. 2, is divided into classes of suitable size, so that certain probabilities $P(A_1)$, $P(A_2)$ .... correspond to certain traffic values A_1, A_2 ....

The congestion $E(n,A_1)$, $E(n,A_2)$ .... corresponding to different traffic values A_1, A_2 ... is now calculated for a few trial values of the number of switches n. On the assumption that, under congestion conditions, the subscribers lose the entire time taken by an average conversation, and that the frequency function describes the whole year, the total loss of time will be

$$\sum_A A \cdot E \cdot P(A) \text{ erlang years}$$

To determine the cost of these losses of time, we place a certain value, g kr/hr, on the subscriber's time and immediately obtain the cost

$$8{,}760 \cdot g \cdot \sum_A A \cdot E \cdot P(A) \text{ kr/annum}$$

or capitalized with the interest factor r

$$G \cdot 24 \sum_A A \cdot E \cdot P(A) \text{ kr}$$

in which expression

$$G = \frac{365 \cdot g}{r} = \text{the capitalized value of 1 hour/day of the subscriber's time.}$$

If b is the capitalized value of a switch unit, i. e. the first cost increased by the present value of the cost of operation, maintenance and replacement, and n is the number of switches, the total cost is

$$b \cdot n + GT \cdot \sum_A A \cdot E \cdot P(A) \text{ kr}$$

In this expression 24 has been substituted by T, or the mean number of hours per day, described by $P(A)$. This time need not necessarily be 24 hours, but can with advantage be considerably less, since measurable traffic losses are caused only by traffic values above a given limit.

The number of switches must now be determined so as to minimize this expression, which represents the cost of switches and the economic value of the inconveniences to subscribers. An example is shown in fig. 3 of how these costs change with the number of switches in a special case for different values of g, viz. 4, 8 and 16 kr/hr.

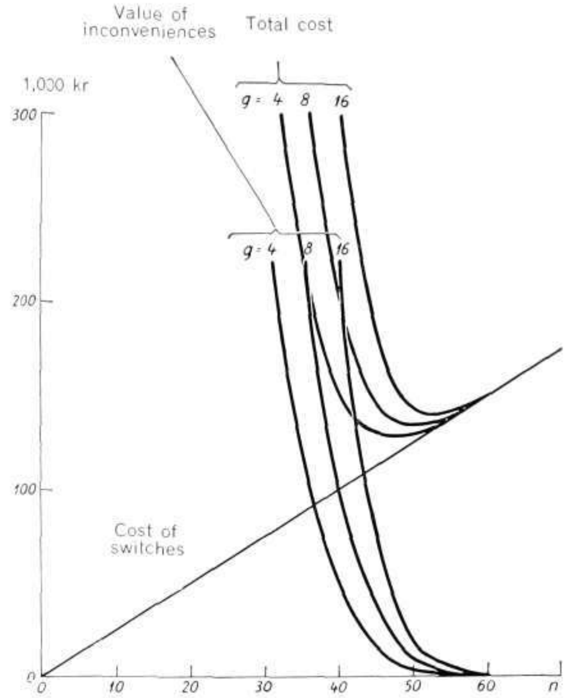

Fig. 3 X 8289

Cost of switches, value of inconveniences and total cost in a special case for $g = 4$, 8, and 16 kr/hr as function of number of switches n

It should be of interest to show the result of a calculation of the number of switches and of the congestion arising in a switching stage under different assumptions concerning the value of the subscribers' time. In order to be able to do this in a simple and clear manner, we assume that the frequency function for the traffic can be substituted by a single value applying during a certain period. It should perhaps be stressed that an assumption of this kind has nothing in common with the traditional concept of "busy hour traffic", but relates to an "equivalent traffic" corresponding to the "tail" of the frequency function, which, within certain limits as regards the cost of switches and the value of subscribers' time, gives the same number of switches as would be obtained by including all traffic intensities during the year and their duration.

Assume, for example, that a switching stage carries the traffic from $N = 500$ subscribers, which can be represented by a single value $A = 30$ erlangs applying during 1 hour per day. The switch cost is $b = 500$ kr per switch and the interest factor $r = 0.08$, and we wish to calculate the number of switches under different assumptions as regards the value of subscribers' time, g kr/hr.

The result of the calculations under these assumptions is shown in table 1.

Table 1. Number of switches, congestion and losses of time in a switching stage under different assumptions as regards the value of subscribers' time, g kr/hr, provided that the frequency function for the traffic during the year can be represented by a single value $A = 30$ erlangs applying during 1 hour per day.

$N = 500$ subscribers, $b = 500$ kr/switch, $r = 0.08$

Value of subscribers' time		Number of switches	Congestion	Mean time losses in switching stage per subscriber
g kr/hr	$G = \frac{365 \cdot g}{r}$	n	E	$\frac{AE}{N} \cdot 3{,}600$ sec./day
1	4,563	41	0.010	2.2
2	9,125	43	0.0051	1.1
4	18,250	45	0.0023	0.5
8	36,500	47	0.00096	0.21
16	73,000	49	0.00037	0.080
32	146,000	50	0.00022	0.048
64	292,000	51	0.00013	0.028
128	584,000	53	0.00004	0.009

It is apparent from the table, first and foremost, that if the value of the subscribers' time changes in geometric progression, the number of switches changes practically in arithmetic progression, which proves that the result is affected solely by the order of magnitude of the value one places on the subscribers' time. It is also interesting to note that an administration, which, for example, has based its provision of switches on the postulate that the congestion in the switching stage shall not be above about 0.002, may be said to have done this *as if* the value of the subscribers' time had been about 4 kr/hr. If the cost per switch had been 2,000 instead of 500 kr, this means that, for the same level of congestion, one has calculated *as if* the value of the subscribers' time had been about 16 kr/hr. If, however, we postulate that the value of the subscribers' time shall be constant, say $g = 8$ kr/hr, the number of switches for the cheaper and more expensive switching stages will not be equal, i. e. 45 switches, but in the former case one should install 47 and in the latter 43 switches, so that the congestion will instead be about 0.001 and 0.005, respectively.

In the last column in table 1 the mean loss of time suffered by each subscriber in the switching stage is indicated in seconds per day. Thus, from the economic aspect, it is these seconds which determine the requirement of switches in a switching stage. The subscribers' total loss of time, however, is greater than indicated in the table since a telephone connection passes through several switching stages. At, for example, 8 kr/hr and with five equivalent switching stages for the connection to pass through, the loss of time will be about 1 second per day.

In attempts to determine G, representing the capitalized value of the subscribers' time, it is reasonable and natural to assume that the value of a telephone connection shall exceed its cost. Say that the capitalized value of a telephone plant, including operation, maintenance and replacements, is 4,000 kr/subscriber and that the mean conversation time is 0.4 hr/day. The capitalized value of the subscriber's time must then be greater than $G = \frac{4{,}000}{0.4} = 10{,}000$ kr if the plant is to pay its way. This corresponds to a value $g = \frac{10{,}000 \cdot 0.08}{365} = 2.19$ kr/hr. Say, instead, that the telephone tariffs correspond to a cost of 4 kr/hr, G must then be greater than $\frac{365 \cdot 4}{0.08} = 18{,}250$ kr. For other methods of estimating G reference should be made to the paper in Ericsson Technics.

The use of this economic constant for dimensioning of traffic routes implies that one takes account of the switch cost when determining the number of switches required and so dimensions one's plant on the same economic level. The constant G is therefore a measure of the quality of service which the administration wishes to maintain, which is ultimately a question of commercial policy.

The Conductor Diameter in Subscribers' Cables and the Reference Equivalent of Telephone Circuits

It has now been shown how the losses of subscribers' time which arise on a traffic route can be evaluated in monetary terms and can serve as guidance for determining the switch requirements.

Analogously, it is possible to evaluate the losses of time due to unsatisfactory transmission and use them for guidance in determining the most suitable level of reference equivalent.

Extensive tests carried out in L M Ericsson's laboratory by H. Hansson, and a statistical analysis of his results by G. Lind, have shown that conversation time is likely to be prolonged as soon as the overall reference equivalent on a circuit

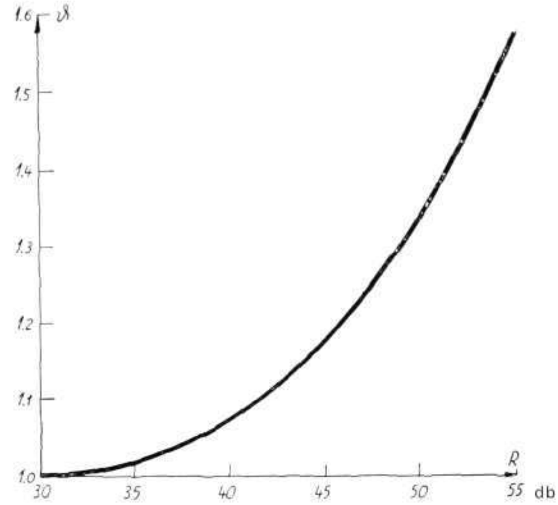

Fig. 4 X 2601

Prolongation factor ϑ as function of the overall reference equivalent R

$$\vartheta = e^{7.34 \cdot 10^{-4}(R-30)^2}$$

exceeds 30 db and that the prolongation of conversation time can be described by an exponentially growing function of the overall reference equivalent (fig. 4).

The reference equivalent for a telephone circuit can be obtained as function of the conductor diameter in the subscribers' cables as soon as the characteristics of the telephone sets and the attenuation in exchanges and trunk circuits which are independent of conductor diameter are known.

The costs of the cable networks and the value of the subscribers' lost time can thus be calculated for given diameters of conductor under certain assumptions concerning the geographical distribution of the subscribers and concerning the traffic initiated by them.

And lastly, it is thereby possible to determine conductor diameters and the corresponding reference equivalent which, for a given network configuration, give the lowest sum for the cost of subscribers' cables and the economic value of subscribers' inconveniences in respect of transmission losses.

An example is shown in fig. 5 of how the upper limit for the reference equivalent for 99 per cent of the calls in a plant consisting of two identical networks linked by a trunk circuit changes with the relation

$$\xi = \frac{\text{cost of 1 mm}^2\text{ conductor}}{\text{value of telephone calls}}$$

under the assumptions given in the legend.

If, for example, the value of the subscribers' time on trunk calls is $g = 80$ kr/hr, the average time of conversation on trunk calls 0.01 hr/day, and the average cost of a subscriber's line with 1 mm² conductors 730 kr, the above relation, at an interest factor $r = 0.08$, will give

$$\frac{730}{0.01\,\dfrac{80 \cdot 365}{0.08}} = 0.2$$

which shows that the reference equivalent for 99 per cent of calls should not be above 31–35 db, provided that the part of the reference equivalent which is independent of conductor diameter is $R_0 = 10$–20 db. The mean prolongation of conversation time is 0.001–0.003 and the mean reference equivalent 21–28 db.

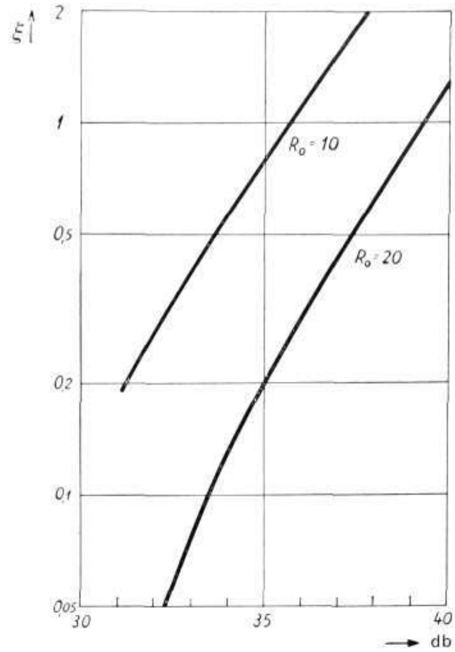

Fig. 5 X 2602

Example of upper limit of reference equivalent for 99 per cent of the calls on a trunk circuit between two identical networks.

Reference equivalent independent of conductor diameter $R_0 = 10$, $R_0 = 20$.

Longest subscriber line 5 km.

Prolongation factor

$$\vartheta = e^{7.34 \cdot 10^{-4}(R_{yx} - 30)^2}$$

R_{yx} = reference equivalent on calls from a subscriber at distance y to a subscriber at distance x from the exchange ($R_{yx} = R_{xy}$, $R_{yx} > 30$ db).

Geographical distribution:

Distance from the exchange Km	0–0.5	0.5–1	1–1.5	1.5–2	2–2.5	2.5–3	3–3.5
Per cent of subscribers	15	22	20	15	11	7	4

Distance from the exchange	3.5–4	4–4.5	4.5–5
Per cent of subscribers	3	2	1

For the remaining 1 per cent of the calls the reference equivalent in the example adduced will be higher, and for calls between subscribers on the periphery of the networks will be about 45 db. At so high a reference equivalent the intelligibility is greatly impaired. It is apparent from fig. 4 that at 45 db one may expect a prolongation of conversation time of around 18 per cent. This shows that measures must be taken to improve the transmission for these subscribers.

An examination of this question shows that, for example, the introduction of repeaters and of special telephone sets with low sending and receiving reference equivalent would be economically warranted provided that the cost of such measures is not too high.

But for a more detailed study of these and similar questions, such as the division of the overall reference equivalent into sending and receiving, and what proportion of the improvement in the characteristics of telephone sets shall be given to the subscribers or used to lower the cost of the cable plant, reference must be made to the papers in Ericsson Technics.

Economic Optimum for Conductor Diameter and Number of Switches

The principle of the calculations sketched in the foregoing, the aim of which is to establish the number of switches and traffic losses on trunk routes and the conductor diameter and reference equivalent for transmission circuits, is graphically illustrated in fig. 6.

This figure shows that the *conductor diameter* determines

the cost of subscribers' cables
the reference equivalent
the prolongation of conversation time
the cost of the subscribers' time

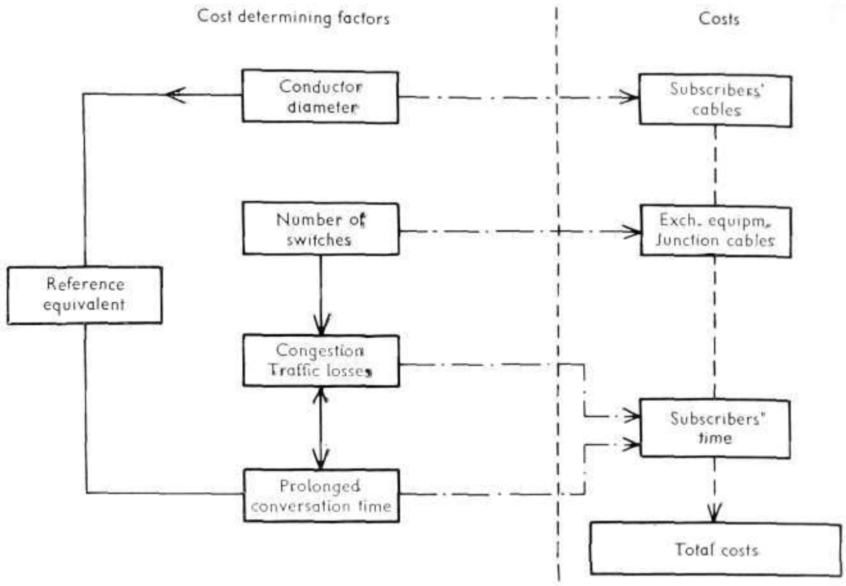

Fig. 6 X 8310

Graphic representation of costs and cost-determining factors in conjunction with the following problem:

Determine the conductor diameter and reference equivalent in subscribers' cables, and the number of switches and traffic losses in the exchange equipment and junction cables, for a telephone plant with given number of subscribers and given quantity of traffic so that the aggregate cost of subscribers' cables, exchange equipment and junction cables, and of the subscribers' loss of time, is a minimum.

and that the *number of switches* determines

the cost of exchange equipment and junction cables
the congestion and traffic losses
the cost of the subscribers' time

The economically best solution is achieved for values of conductor diameters and numbers of switches such that the sum of

the cost of subscribers' cables
the cost of exchange equipment and junction cables
the cost of the subscribers' time

is a minimum.

Since a prolongation of conversation time leads to an increase in initiated traffic, the traffic losses and the prolongation of conversation time are clearly interdependent to some extent and, therefore, the conductor diameters and the number of switches must, in principle at least, be determined simultaneously. This interdependence, which is slight, is intimated in the figure. Only on routes with very heavy traffic can the prolongation of conversation time affect the number of switches.

Summary

In the papers reviewed, an attempt has been made to set up an economic yardstick to provide guidance in determining the time when a decision should be made to extend plant and the quantity of plant to be planned for. The subscribers' interests are placed in the forefront by assuming that their time has a certain value and that they therefore suffer economic losses as soon as the plant shows defects in respect of accessibility and intelligibility.

The economic evaluation of the inconvenience to subscribers is done with the aid of the factor G, which may be said to represent the capitalized value of 1 hour per day of the subscribers' time, and the costs of these inconveniences are weighed against the plant costs so that their sum is a minimum.

The use of this factor G means that one can relate to the same denominator things as different as the number of switches and the diameter of conductors, traffic losses and reference equivalent. The factor provides guidance in making decisions concerning the dates at which different parts of a telephone plant should be extended and concerning the quantities of equipment to be installed, so that the decisions may be made on one and the same economic level. The magnitude of the factor is an expression of the quality of service offered by an administration.

L M Ericsson's Multi-Frequency Code Signalling (MFC) System

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The method of transmitting the numerical information in a telephone network has an important bearing on the operating properties of the entire plant. It is therefore important to choose a signalling system which is reliable and rapid, is applicable to all types of circuit, and requires little maintenance. These requirements are met by the signalling system with compelled sequence v.f. code, known as MFC (Multi-Frequency Code) Signalling, which is employed in several Ericsson telephone systems. This article describes the principles and applications of this signalling system, while the equipment itself is dealt with in the following article.

To establish a connection through one or more automatic telephone exchanges the numerical information is transmitted from the originating exchange to switching stages along the route. Transmission of numerical information in the forward direction is often combined with backward signalling to control and supervise the setting up of the connection. In a register-controlled telephone system this exchange of information takes place between a register at the originating exchange and devices (selectors, registers, or other type of receiver) at the various switching points on the route. The signals are called register signals and are thus used only during the setting up of the connection.

For supervision of the connection before, during and after its establishment, other signals are required, known as line signals. In view of the different requirements placed on register signals and line signals, it is useful to separate the equipments used for each. The line signalling equipments can thereby be simplified and designed specifically for the respective types of circuit. Since register signalling is required only during the brief period taken to establish a connection, this signalling equipment can be concentrated to common units.

The register signalling takes place at a time when the speech channel cannot yet be used for its proper purpose – the conversation between the subscribers. The speech channel is therefore available for register signalling, and consequently the signalling system can be very rapid and applicable to any type of circuit.

In a telephone system with rapid transmission of information combined with rapid switching equipment, the time of occupation of circuits and switches during the setting up of the connection is very small. In a system of this kind there will be no undue delay in setting up the connection if the start of the process is postponed until all or almost all of the digits have been dialled. The economic saving that this involves is especially noticeable on trunk circuits and in trunk exchanges, which are the most expensive elements in a telephone network. The rapidity of the numerical transmission, moreover, permits transmission of the larger quantity of information which may be required for choice of the most economic route to the destination exchange. This also contributes to optimal utilization of the entire telephone network.

It is of fundamental significance that the register signalling system is usable on all types of circuit, on physical circuits with and without transformers

as well as on different types of carrier circuit, and that the range of the system is sufficient to cover all types of traffic encountered in practice. Consequently the exchange equipments can be standardized, and repetition and translation of signals at certain switching points can be avoided.

The register signalling system developed by L M Ericsson follows these principles and fulfils these requirements.

Signalling Principle

MFC (*M*ulti-*F*requency *C*ode) signalling employs v.f. signals, each signal consisting of two simultaneous frequencies. For a receiver to react, it must identify two and only two frequencies.

L M Ericsson's system employs forward signals (numerical signals) and backward signals (controlling signals). The signalling scheme provides for six frequencies for numerical signals and six for controlling signals as tabulated below.

	Frequency in c/s					
Numerical signals	1380	1500	1620	1740	1860	1980
Controlling signals	1140	1020	900	780	660	540
Signal no. 1	×	×				
2	×		×			
3		×	×			
4	×			×		
5		×		×		
6			×	×		
7	×				×	
8		×			×	
9			×		×	
10				×	×	
11	×					×
12		×				×
13			×			×
14				×		×
15					×	×

The scheme allows for 15 numerical signals and 15 controlling signals.

A numerical signal thus consists of two of the frequencies 1380, 1500, 1620, 1740, 1860, 1980 c/s, and a controlling signal of two of the frequencies 1140, 1020, 900, 780, 660, 540 c/s.

Signalling takes place from a register to a code receiver (or register) in a switching stage on the path to the called exchange. The receiving unit may thus be located in the home or another exchange. The signalling is done with continuous compelled sequence signals on the following principle (fig. 1):

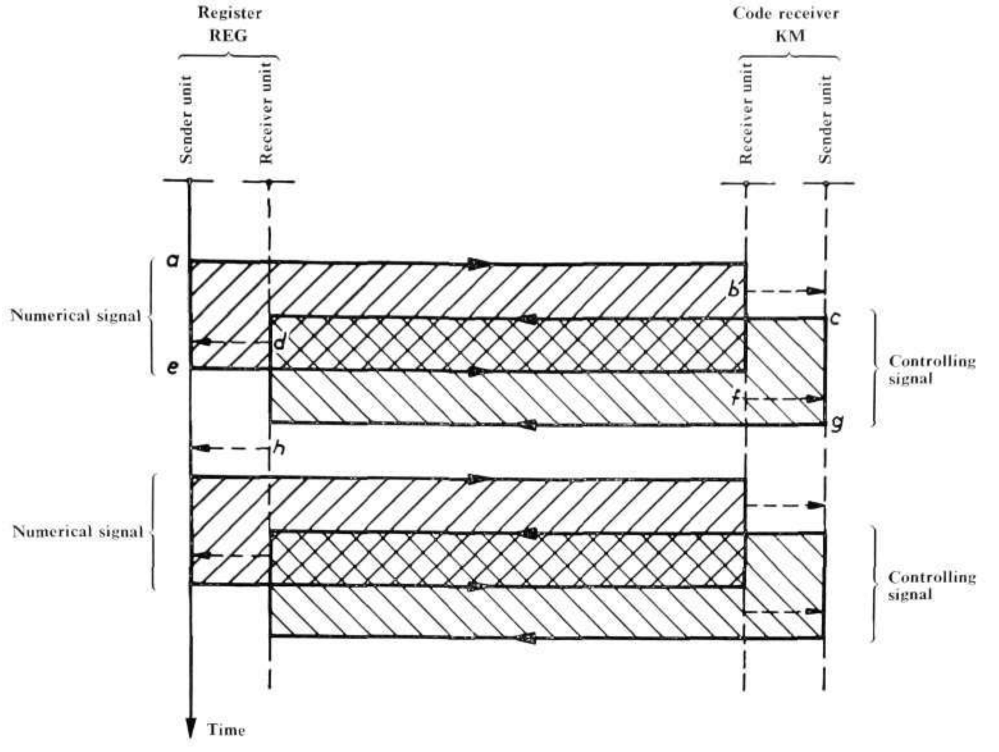

Fig. 1 X 8329

Time-sequence diagram for MFC-signalling

a. A continuous numerical signal is sent from the register (*REG*).

b. The code receiver *KM* recognizes both frequencies of the signal and identifies the signal.

c. A continuous controlling signal is sent from *KM*. Thus at this stage there are four frequencies simultaneously on the circuit between *REG* and *KM*.

d. The register recognizes both frequencies of the signal and identifies the signal.

e. The sending of the numerical signal from the register ceases.

f. *KM* recognizes that both frequencies of the numerical signal have ceased.

g. *KM* interrupts the sending of the controlling signal.

h. When the register perceives that both frequencies of the controlling signal have ceased, the register proceeds to send the next numerical signal.

The register can thus send a numerical signal immediately after seizure of the circuit, and the signal persists until the receiver has been connected and sent a controlling signal in acknowledgement. This saves time since a proceed-to-send signal is unnecessary.

A code receiver does not send a controlling signal if the numerical signal it is receiving is required as first numerical signal by the subsequent code receiver. Thus the sending register need not repeat this numerical signal but continues transmitting until it receives a controlling signal.

The system allows transmission of 6–7 digits per second with the relay technique employed.

Meaning of the Signals

The main purpose of the numerical signals is transmission of numerical information (digits *1–0*) within the home exchange or to other exchanges, and for this, of course, ten signals suffice (signal nos. *1–10*). But there is often a need for other signals, and therefore six frequencies are used, which allows fifteen numerical signals.

For the controlling signals, only four of the six available frequencies are generally employed (1140, 1020, 900, 780 c/s), making six controlling signals. Depending on the phase of signalling in which they occur, the controlling signals have three different meanings and are called A-, B- and C-signals, the change from one to another being controlled by certain A- and C-signals in accordance with the schemes listed below.

During the setting up of the connection the code receivers *KM* send A-signals in acknowledgement of the numerical signals, and by means of different A-signals *KM* can control the transmission of the information needed at different points along the switching path. The A-signals normally have the following significations:

A1 Send next digit of the number
A2 Send first digit of the number
A3 Change to B-signals
A4 Congestion
A5 (Spare)
A6 Change to C-signals

The spare signal, *A5*, is needed in certain cases, for example to arrange for change to decadic pulsing.

When the connection has reached the destination exchange and the number has been received there, *controlling signal A3* is sent to inform the register that the digit transmission shall stop and that the next controlling signal shall be interpreted by the register as indication of the condition of the called party's line. In reply to controlling signal *A3* the register returns a numerical signal as information of the traffic category, e.g.:

1 Call from operator
2 Call from ordinary subscriber
3 Call from pay station
4 (Spare)
5 (Spare)
6 Call from test equipment
7 Trunk offering if line engaged
8 Through-connection to called party despite interception of line
9 Interception to be discontinued
10 Called line to be placed on interception

This numerical signal is acknowledged with a *B-signal*, with the following signification:

B1 Called party free, charged call
B2 Engaged
B3 Number intercepted (or unassigned number)
B4 Congestion
B5 Called party free, no charge
B6 Malicious call tracing (or unassigned number)

If the calling party's category or identity is to be transferred from the originating exchange to a receiving unit (register or code receiver) along the route, the unit returns *controlling signal A6* back to the register at the originating exchange. The register replies with a numerical signal which, like the acknowledgement of *A3*, gives information of the traffic category. The receiving unit then sends a *C-signal* with the following signification:

C1 Send next digit

C2 Send first digit of called number (change to A-signals)

C3 Change to B-signals

C4 Congestion

C5 Send next digit of called number (change to A-signals)

C6 Send same digit of called number (change to A-signals)

When the originating exchange register receives *controlling signal C1*, it sends the first digit of the caller's number, which is acknowledged with a new *C1* signal by the receiving unit. The register then sends the second and remaining digits in the same way. When the register receives *C1* after having sent the last digit, it replies by sending numerical signal *15* as indication that all digits have been transmitted. The subsequent C-signal causes reversion to sending of the called number according to the code scheme, whereupon the controlling signals resume their A-significations.

Controlling signals *C2*, *C5* and *C6* can also be used if the receiving unit wishes to interrupt the transmission of the caller's identity because it has received a sufficient number of digits. When the register receives one of these signals, it sends the requested digit of the called party's number and the subsequent C controlling signals have the character of A signals.

If for any reason the register cannot supply information of the caller's identity, on receipt of controlling signal *A6* it immediately replies with numerical signal *15*, and the receiving unit is thereby enabled to handle the connection in a special way.

Through the use of C signals an enquiry concerning the caller's identity can be made in any phase whatsoever of the connection, and the transmission of the caller's number can be interrupted and a reversion made to sending of the called number when sufficient information has been supplied to the receiver.

Summary

The use of compelled sequence signalling means that the signal equipments are simple to adjust and keep in order, and so require little maintenance since there are no time conditions. The signalling speed is determined by the operating times of the various components in senders and receivers, and these times can be prolonged or shortened without impairment of the signal performance. In the event of a fault during transmission of signals, the registers and code receivers stop on the phase in which the fault occurred, which assists in fault tracing.

Every switching point in the network can control the transmission of precisely the information needed for positioning of the switches, and it is a simple matter to readjust the code receiver so as to acknowledge with the desired controlling signal. The signalling scheme permits the insertion of additional signals so as to comply with any future demands for transmission of additional information. This makes the system flexible, an important point in a telephone network which is continuously expanding.

L M Ericsson's Multi-Frequency Code Signalling (MFC) Equipment

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This article gives details of the most important transmission requirements for L M Ericsson's MFC signalling system. The method of operation and a description of the v.f. signalling equipment with technical data are also given.

Technical Requirements

The need for rapid interchange of information between registers in automatic exchanges has led to different telephone administrations and manufacturers of telephone equipment, among these the L M Ericsson Telephone Company, developing their own voice frequency signalling systems for this purpose during the 1950's.

At the beginning of 1958, the Netherlands Telephone Administration, with praiseworthy initiative, invited telephone administrations and manufacturers in Europe to a meeting which had the object of standardizing the characteristics and applications of a v.f. code signalling system, so as to facilitate the interoperation of telephone stations of different manufacture. From the transmission point of view, the results of the investigations which were made in connexion with a meeting at The Hague on 4th–7th March 1958, and at later meetings, constitute the basic requirements for L M Ericsson's new multi-frequency code (MFC) signalling system. Among the most important requirements of the design of the system, the following can be mentioned:

The use of compelled sequence signalling on two-wire and four-wire lines with 15 different criteria in the outgoing direction of the traffic and with the possibility of having the same number of criteria for the return direction led to a system having 6 frequencies in the outgoing direction and up to 6 in the return direction. By permitting each signal to consist of 2 frequencies simultaneously out of the possible 6, a self-checking code with 15 combinations for each direction is obtained. There is very little probability of a disturbance causing incorrect operation of v.f. signalling receiver for exactly two frequencies simultaneously.

The usable frequency range is restricted to 500–2000 c/s, as one must avoid mutual influence between the signalling and tones below 500 c/s or v.f. line signalling above 2000 c/s. In addition it is desirable to limit the upper frequency to 2000 c/s, since junction lines may sometimes consist of loaded cables with low cut-off frequency. The frequencies of 1380, 1500, 1620, 1740, 1860 and 1980 c/s have been chosen for signalling in the outgoing direction. The frequencies for the return direction are 1140, 1020, 900, 780, 660 and 540 c/s, the lower frequencies being omitted where the complete number of signals is not required.

Signalling is assumed to take place between registers or other equipment which in certain cases can be situated at stations of such low rank as terminal exchanges. The attenuation in the transmission path can vary between zero and the maximum value between the stations in question in the actual network. An important characteristic of the signalling system is therefore its

range and the permissible variation of its receiving level. Based on information from different telephone administrations, the range which is economically motivated has been set at 30 db, thus covering the major part of possible applications. The signalling level on the line is limited by the risk of interference in adjacent channels, due among other things to crosstalk in carrier systems, and has been fixed by CCITT at –5 dbm max. referred to a point of zero relative level at the highest signalling frequency used. The nominal signalling level has been chosen to be the same for all frequencies and is –8 dbm per frequency, which gives –5 dbm for a signal consisting of two simultaneous frequencies. The working range of the signalling receiver has been fixed at levels between –6 dbm and –38 dbm per frequency.

For the MFC equipment to be universally applicable, it must not, within the above-mentioned working range, place any special requirements on the transmission path beyond those applying for normal good quality transmission of speech. In addition to noise, regard must be paid to interference which can arise due to intermodulation, momentary interruptions in the transmission path and sending of signals with steep flanks at the start and finish. If, for example, compandors are used on a circuit, they give rise to relatively strong intermodulation due to their regulating action, following the beat frequency of the signal envelope, when the two simultaneous signalling frequencies have a small frequency difference. Hence, the signalling receiver must operate reliably with high intermodulation on the connexion and to be able to accept steep signalling wave fronts.

Design and Method of Operation

The principle of the construction of the v.f. signalling equipment will be seen in the block schematic, fig. 1. The equipment can be divided functionally into an A-terminal belonging to the telephone exchange outgoing equipment and a B-terminal belonging to the incoming exchange equipment. The signalling is always connected on a two-wire basis to the line, so that 4-wire lines are terminated 2-wire before being connected to the MFC equipment.

Fig. 1 X 7824 X 9154

Block schematic of MFC equipment

VF generator

Channel signalling receiver

Regulating amplifier

Low-pass filter

High-pass filter

KS Code transmitter

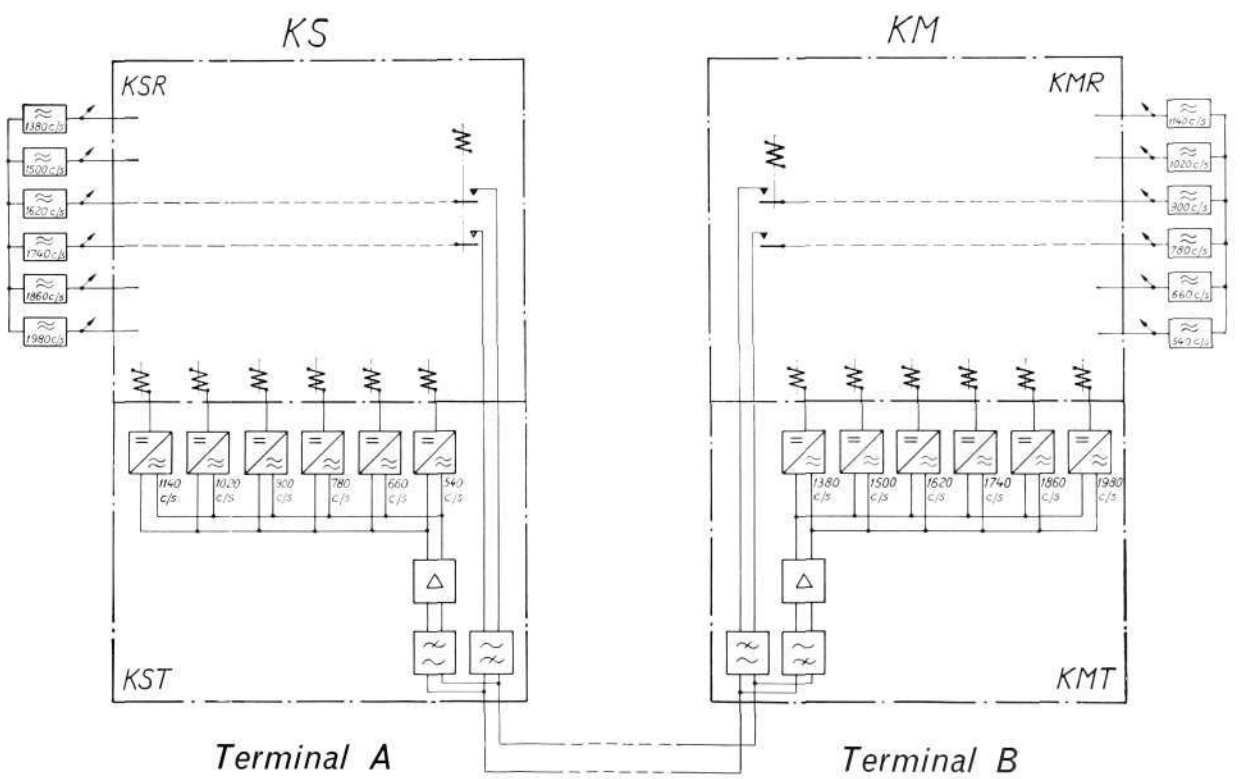
KSR Relay equipment for code transmitter

KST VF code equipment for code transmitter

KM Code receiver

KMR Relay equipment for code receiver

KMT VF equipment for code receiver



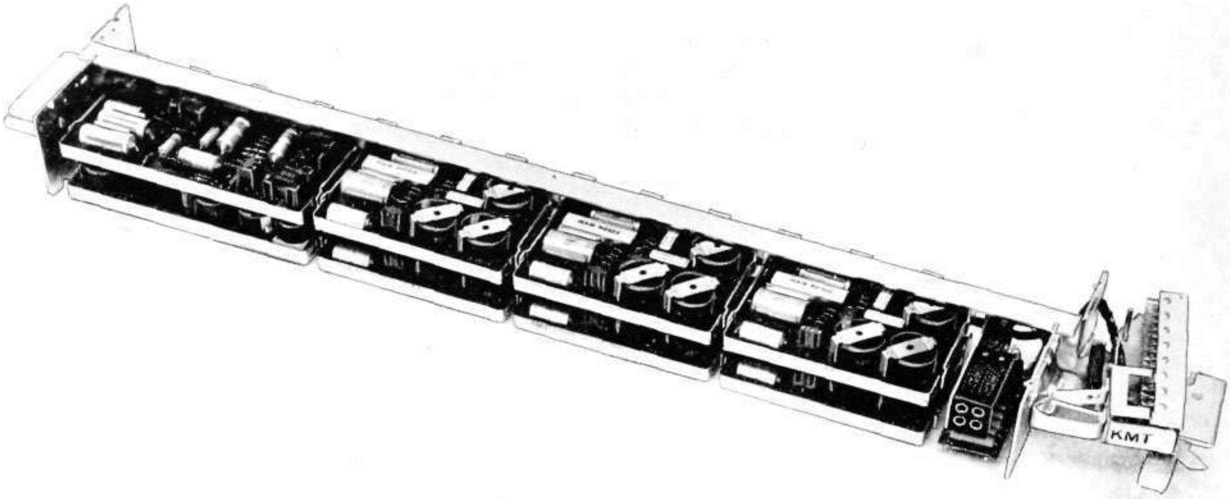


Fig. 2 X 7828

Relay shelf

containing directional filters and v.f. receiving equipment for B-terminal

Signals consisting of two simultaneous frequencies of the six frequencies in the sending direction, viz. 1380, 1500, 1620, 1740, 1860 and 1980 c/s, are sent from an A-terminal. The frequencies are obtained from a generator equipment which can be common to several sets of sending equipment for several circuits and can be provided with arrangements for automatic change-over to a stand-by generator in the event of a fault occurring in a regular generator. One distribution transformer per frequency is included in the equipment for matching the generator voltage to the correct sending level on the line. One terminal of a distribution transformer is connected to the corresponding terminal of the next transformer. When sending, the second terminal for the frequencies in question is connected via distribution resistors to its line leg by means of relay contacts in the sending device. The signalling passes out to the line via the high-pass part of a directional filter. The impedance to the line is either 600 or 800 ohms.

Signalling coming in from the line to an A-terminal passes through the low-pass section of the directional filter. The attenuation in the stop band of the low-pass filter prevents the signalling frequencies which are sent out from the A-terminal from affecting the regulating amplifier on the receiving side. As the high-pass section of the directional filter has a high impedance in the stop band, shunting of the receiving side when sending signalling is avoided. The regulating amplifier has the duty of amplifying the incoming signals. In addition, its output level is maintained practically constant when the input level exceeds a certain value. The regulating amplifier output is connected to a selective channel signalling receiver for each of the signalling frequencies used. The four frequencies 1140, 1020, 900 and 780 c/s are often the only frequencies used. Addition of the frequencies 660 and 540 c/s may be carried out by supplementing the equipment with signalling receivers for these frequencies. When signalling of the correct frequency enters a channel signalling receiver, its dry-reed relay is operated which in turn operates the relay equipment of the A-terminal.

The design of a B-terminal follows the same principles as for an A-terminal except that the frequencies 1380 to 1980 c/s are received and 1140 to 540 c/s are sent. Mechanically, the equipment is mounted on laminated plastic boards[1], the combination having L M Ericsson's type designation ROA. The boards have etched copper foil wiring, and connexion to the relay sets is made by means of plug and jack.

[1] G Neovius: *Printed Circuits — A New Production Technique*. Ericsson Rev. *35*(1958): 4, pp. 125—127.

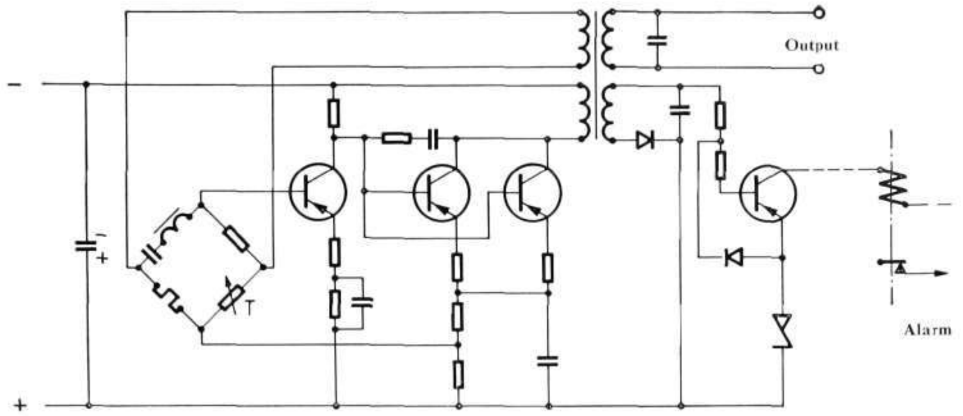


Fig. 3 X 8297
Circuit diagram of v.f. signalling generator

Generating Equipment

The generators for all frequencies have the same basic design and consist of bridge stabilized oscillators with two transistors connected in parallel in the output stage (see fig. 3). The working points of the transistors are stabilized against changes due to variations of transistor characteristics, ambient temperature etc. by using d.c. feedback. The nominal output voltage is 7.75 volts and the maximum output power is at least 50 mW with 2.5 % harmonic distortion. The tolerances are ± 1 db in level and ± 5 c/s in frequency. However, the difference in level between any two frequencies is not more than 1 db.

The output transformer of the generator is provided with a separate winding which is used to provide a voltage for supervising the output level. This voltage is rectified, amplified in a transistorized circuit and applied to a separate relay. This relay can be arranged to give alarm and also to change over to stand-by generator when the output voltage falls by more than 4 db below the nominal value. The voltage at which this supervisory circuit is not affected is 2 db below nominal.

Signalling Receiver Equipment

Compared with the usual 1–VF and 2–VF signalling receivers for line signalling, the design of a signalling receiver for register signalling is a simplification, as no protection against signalling imitation by speech is required. On the

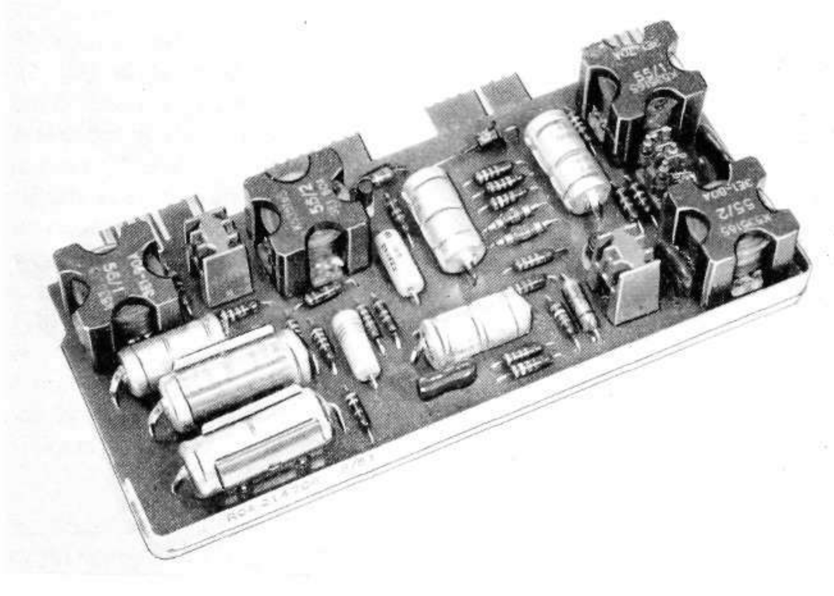


Fig. 4 X 8304
Regulating amplifier unit

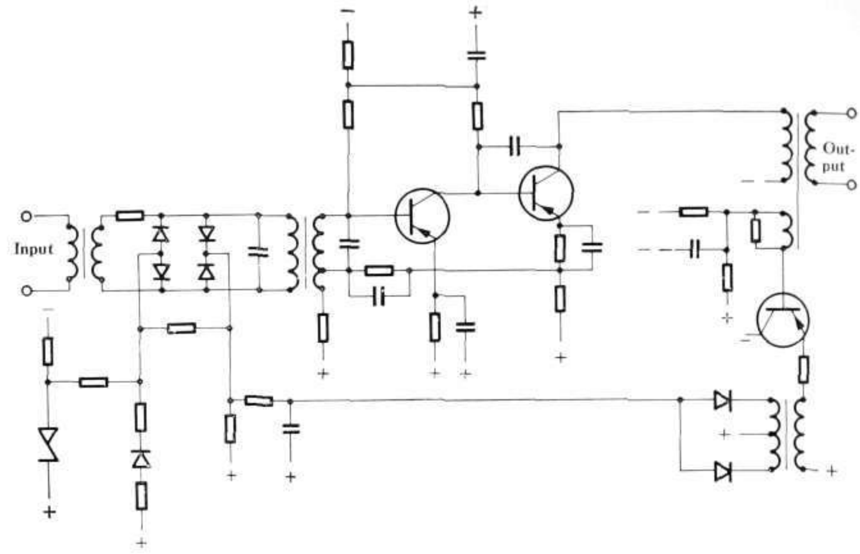


Fig. 5 X 8298
Circuit diagram of regulating amplifier

other hand, of course, its relatively large working range and the number of frequencies means aggravating conditions. The principle of using a common regulating amplifier for all the received frequencies has been employed in the same way as in L M Ericsson's v.f. code signalling receiver for MFC impulsing of earlier design. By regulating the receiving sensitivity for all the signalling frequencies to the value which corresponds to the level of the incoming signalling, an active protection is obtained against interference of the signalling due to intermodulation in the transmission path. Individual regulation would mean that only the two signalling channels which receive a signal are regulated while the remainder retain their maximum sensitivity. There would thus be a great risk that interference signals which arise when signalling is transmitted would cause false operation.

The principle of common regulation, however, means a limited permissible level difference between the two frequencies constituting a signal. This difference, measured at the input of the directional filter, has been set to 5 db max. This means that the range of the system is limited by attenuation distortion of the line only when this consists of unloaded cable. A larger permissible difference in level would mean increased demands on the selectivity of the channel receivers, which would in turn affect their response time and thereby the system signalling speed.

The regulating amplifier (fig. 5) consists of a two-stage amplifier with a variable attenuating network consisting of biased diodes at the input. The regulation to a relatively constant output voltage for all input voltages above a certain value is done by extracting a regulating voltage from the output transformer. This voltage is amplified in a transistor, rectified and is applied to the diodes which receive current in the forward direction and reduce the input signals when the regulating voltage fed back exceeds the bias voltage. From the point of view of stability, the time constants in the regulating circuit are chosen so that regulation of the sensitivity in the downward direction occurs rapidly, while regulation in the upward direction is relatively slow, which also contributes to the prevention of false relay operation due to echoes. Before the receiver has regained its full sensitivity, the echo has died out. All transistors in the regulating amplifier are stabilized by d.c. negative feedback.

The individual channel signalling receivers are connected with their inputs in parallel at the output of the regulating amplifier. The circuit diagram (fig. 7)

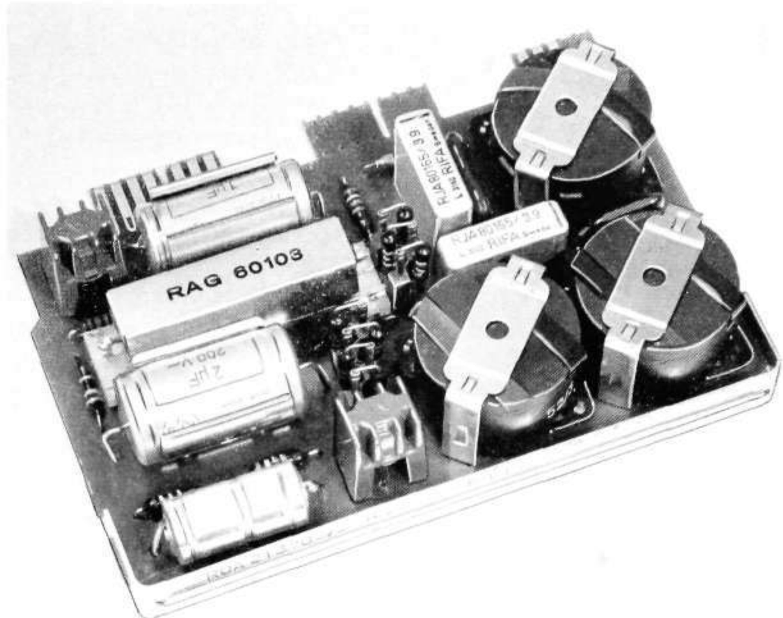


Fig. 6 X 8305

Channel signalling receiver unit

of the channel signalling receivers is the same for all frequencies. The signalling receiver consists of a band-pass filter for the respective frequency, an a.c. amplifier stage and a d.c. amplifier stage, which controls a reed relay. When the input voltage is low, the filter attenuation is high, due to the bias voltage obtained from the regulating amplifier. Feedback cancels this attenuation when the relay current increases. The non-linear input level/relay current characteristic so obtained ensures that the operating and release limits of the signalling receiver are independent of the spread in relay data. The requirements of the band-pass filter, which has approximately 60 c/s bandwidth, is mainly determined by the spacing of 120 c/s between the two signalling frequencies, the quality of the regulation and the difference in level between two frequencies coming in simultaneously. With the chosen selectivity, it has been possible to hold the sum of the operate and release times to less than 35 ms. for input signalling levels between −6 and −36 dbm.

Technical Data

General

Nominal frequencies:

For sending direction 1380, 1500, 1620, 1740, 1860 and 1980 c/s

For receiving direction 1140, 1020, 900, 780, 660 and 540 c/s

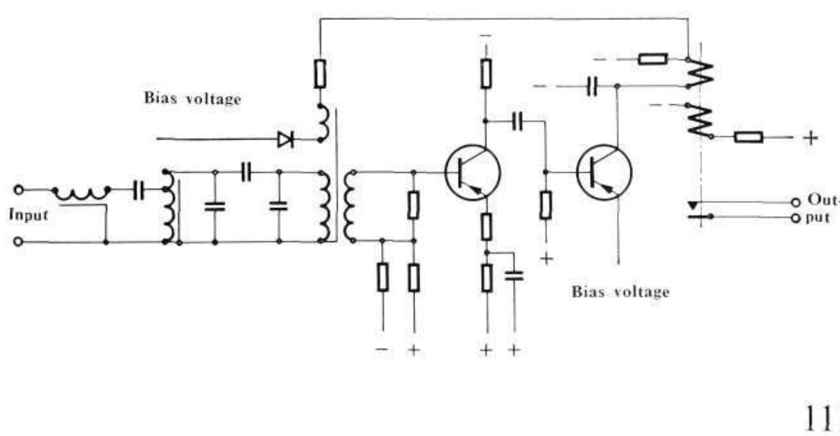


Fig. 7 X 8299

Circuit diagram of channel signalling receiver

Nominal impedance:
600 or 800 ohms

Power supply:
24 V d.c., variation –10 % to +20 %

Ambient temperature:
The data given are maintained over the temperature range +10°C to +40°C

Sending Equipment

Nominal sending level:
–8 dbm per frequency

Tolerances when sending:
The signalling frequencies sent out do not deviate more than ±1 db in level and ±5 c/s in frequency from the nominal values. The maximum difference in level between two frequencies constituting a signal is 1 db.

Alarm and changeover to stand-by generator:
Level limit for non-operation of supervisory circuit is 2 db below nominal.

Level limit for positive operation of supervisory circuit is 4 db below nominal.

Receiving Equipment

Working range:
Permissible variation in level –6 to –38 dbm per frequency, up to 5 db maximum difference in level between two simultaneous frequencies. Permissible frequency deviation ±10 c/s from nominal.

Response time:
The sum of operate and release times is less than 35 ms for signalling levels between –6 and –36 dbm per frequency.

Sensitivity to interference:
The signalling receiver is not affected by an arbitrary frequency having a level which is less than –50 dbm.

Interference frequencies which enter the receiver at the same time as the desired signalling frequencies do not affect any receiver relay, if the interference frequencies have a level which is 25 db lower than the stronger of the desired signalling frequencies.

Crossbar System ARK 50 for Rural Exchanges

R BAGER, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 621.395.344.6
LME 8354

L M Ericsson has developed a telephone system ARK 50 for rural exchanges which uses MFC signalling for transmission of the numerical information and for supervision of the setting-up of connections. The system comprises two types of terminal exchange, ARK 511 and ARK 521, and one group centre type, ARK 523. The present article deals with the general principles of the system, while the different types will be described in a later article.

In the conversion of rural networks to automatic operation, there is usually a need for telephone exchanges which can be economically constructed for a small initial capacity and later be expanded without difficulty as the number of subscribers increases. Regardless of the size of a rural exchange, the subscribers expect to receive the same service as subscribers at larger exchanges. To meet this demand, the rural system must be provided with the same traffic facilities as telephone systems for large towns. The telephone administration, moreover, requires that rural exchanges shall operate so reliably that they can be left unattended and be maintained by a small force concentrated at a few points, thus keeping operating costs at a minimum.

L M Ericsson's telephone system *ARK 50* is designed for the special conditions and requirements of rural networks. It employs crossbar switches in link connection, and the setting of the switches is effected by markers. The system is register-controlled and uses compelled sequence multi-frequency code (MFC) signalling, operating within the voice band, for transmission of numerical information between exchanges and for supervision of the establishment of the connection. This means of signalling, together with the well-known qualities of the crossbar switch, contributes to the flexibility, reliability and low operating costs which distinguish L M Ericsson's rural exchange systems.

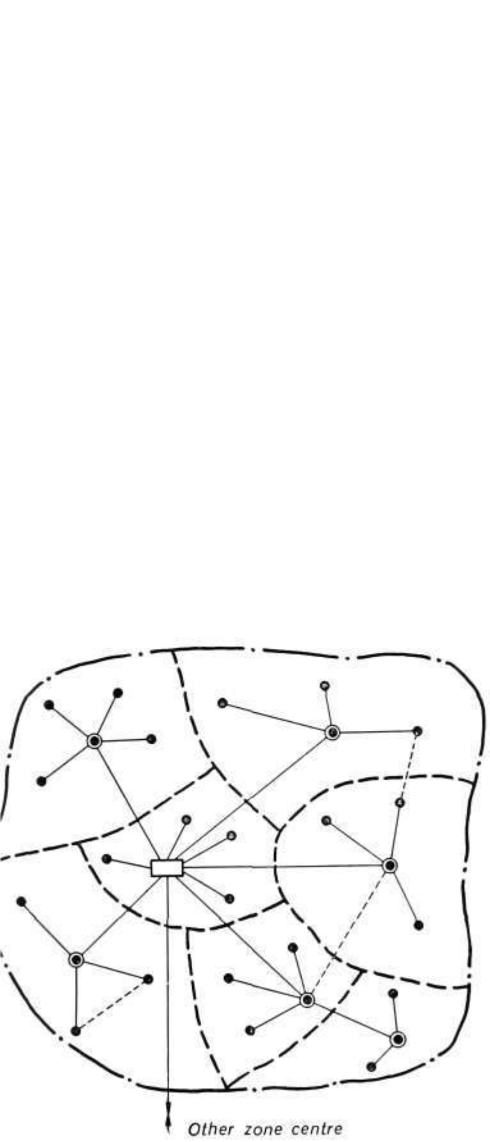


Fig. 1
Zone structure

General Principles

Structure of Network

A telephone network is divided into a number of zones, and the largest exchange within each zone is usually chosen as the zone centre. Traffic to and from other zones passes over the zone centre.

Each zone is divided into a number of group areas, each with a group centre. Traffic to other groups and to the zone centre goes over the group centre. The remaining exchanges in each zone are terminal exchanges, which can be connected either to the group centre or to the zone centre (fig. 1).

The group centres are connected either to the zone centre or to other group centres. Several group centres can be connected in tandem if traffic considerations do not call for direct junctions between the zone centre and certain group centres.

Direct junctions can be established between group centres, between terminal exchanges within the same or different group areas, and between terminal exchanges and group centres (or the zone centre) within different areas. Direct junctions may be designed as high-traffic, high-loss routes for terminal traffic to the group centre or terminal exchange, and are used as first-choice routes. If no direct junction is free, an alternative route is selected via the home group or zone centre.

Exchange Types

The *ARK 50* system for rural networks comprises the following types:

ARK 511 Terminal exchange for 30–90 subscriber lines

ARK 521 Terminal exchange for max. 2,000 subscriber lines

ARK 523 Group centre for group areas with max. 1,500 subscriber lines

The ultimate capacity of the exchanges depends on the traffic load.

A group centre may also be composed of a local exchange *ARK 521* and a transit exchange *ARM 503* or *ARM 201* to which the junction lines are connected. The transit exchanges are described in Ericsson Review No. 2, 1960.

Signalling System

The signalling system is based on division of the signals into line signals and register signals. The first group is used chiefly for supervision of the connection before, during, and after its establishment, the second chiefly for transmission of numerical information and for supervision of the setting-up of the connection.

For *register signals* use is made of v.f. code (MFC signalling), with two out of six frequencies for numerical signals and two out of four frequencies for controlling signals on the principles described in an earlier article in this number.

For *line signals* a discontinuous system is usually employed, with two lengths of signal as shown below.

	A.C. and V.F. signalling	*D.C. signalling*
Seizure	150 ms	Closing of loop
Seizure of Code Receiver	150 ms	Polarity Reversal 150 ms
Answer	150 ms	Polarity Reversal 150 ms
Metering signal	150 ms	Polarity Reversal 150 ms
Clear-back	600 ms	Polarity Reversal 600 ms
Forced-release	600 ms	Polarity Reversal 600 ms
Clear-forward	600 ms	Opening of loop
Release-guard	600 ms	
Operator's signals	150 ms	Opening of loop 150 ms

On routes where simultaneous signalling in both directions is not possible, a 1,500-ms clear-forward signal is employed.

On a.c. circuits a 25-cycle frequency is used; but for signalling from terminal exchange to group centre, when dial pulses as well must be transmitted, a roughly 100-cycle frequency is employed.

On carrier circuits v.f. signalling is used. Outband signalling is employed on circuits which carry metering signals, and outband or inband signalling on other circuits.

The signals can naturally be modified for interworking with existing systems.

No disturbance of conversation is caused by any of the signals tabulated above which are sent back from the called to the originating exchange.

The use of the various signals will be briefly described below.

A seizure signal seizes a register or code receiver.

A seizure of code receiver signal seizes a code receiver in the originating terminal exchange.

An answer signal is sent back to the calling exchange when the subscriber answers the call. When the answer signal passes the charging exchange (as a rule the originating group centre), the circuit for sending of metering signals is connected. In certain cases of no-charge calls the answer signal is not returned to the originating exchange.

Metering signals can be sent during conversation from the charging exchange over junctions to the originating terminal exchange.

A clear-back signal is sent from the called exchange when the called party clears. The signal is transmitted only as far as the charging exchange, where time supervision is started. Forced-release of the entire connection occurs after a certain time unless the called party again lifts his receiver, the time supervision being disconnected by the next answer signal.

A forced-release signal can be sent from various points along the switching path back to the originating exchange, where it causes a clear-forward signal to be sent, after which the connection is released.

A clear-forward signal is sent from the originating exchange when the calling party clears or when a forced-release signal is received. The signal causes release of the entire connection and is the only long signal sent in the forward direction. It is thus easily distinguished from the other forward signals, making it possible to release the connection at any time. A clear-forward signal is also sent forward from an exchange on the switching path which sends a forced-release signal backwards.

The release-guard signal is sent in the backward direction as acknowledgement of a clear-forward signal to indicate that release of the connection has been effected at the incoming end of the junction. If no release-guard signal is received, the outgoing junction relay set is blocked and transmits repeated seizure and clear-forward signals in the attempt to cancel the blocking condition. Alarm is issued at the same time. This signal is used only on a.c. and carrier circuits. On d.c. circuits, supervision of the line is effected by acknowledgement of the seizure signal. If this acknowledgement is not received, the outgoing junction relay set is blocked.

Operator's signals are sent for cutting in and out of an engaged circuit and for start of ringing.

Register Control

The *ARK 50* system is register-controlled, the setting-up of a connection being controlled by a register at the originating group centre. The terminal exchanges are not provided with registers but make use of registers in the group centre. This means that, as soon as the subscriber originates a call, a

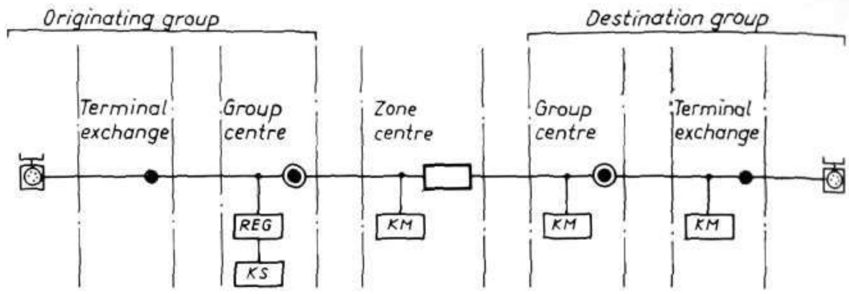


Fig. 2 X 8311

Connection within own zone using MFC-signalling

junction is seized to the group centre and a register is connected there (induced occupation). This register then controls the connection, whether the called subscriber is connected to the same or a different exchange than the caller.

By this arrangement it is possible to centralize and make fuller use of the registers and metering equipment and to avoid placing them in terminal exchanges which are often unattended. It also means that any changes in the numbering scheme and metering can be easily and quickly effected.

The terminal exchange can be equipped with a local register, which is seized if all lines to the group centre are busy. This register can store the necessary number of digits for a local call and control the connection within the local exchange, but returns busy tone if the received digits indicate a non-local call. The local register thus enables local calls to be completed even when all junctions are busy.

The register *(REG)* can usually directly control the connection within the zone by sending digital information by MFC (from code sender *KS*) to code receivers *KM* at the exchanges passed by the connection and at the called exchange (fig. 2).

If the called exchange is not equipped for MFC signalling, the control of the connection can be taken over by the registers in the zone centre. In fig. 3 an example is shown of a connection to a group area with decadic signalling. The register at the originating exchange sends the digital information by MFC to a register equipped with a code receiver *KM* in the zone centre. The latter register forwards the information in the form of decadic pulses from a pulse sender *IS* for direct setting of the switches in the called exchange.

For traffic between two zones, the register at the originating group centre can control the entire connection to the called exchange if all the exchanges involved operate with the same MFC signalling system. In such case, however, the originating register must have information about the numbering scheme in other zones, and such an arrangement is not always the most suitable. For practical reasons, it may be better to limit the register functions to the numbering scheme of its own zone and make use of an incoming register in the called

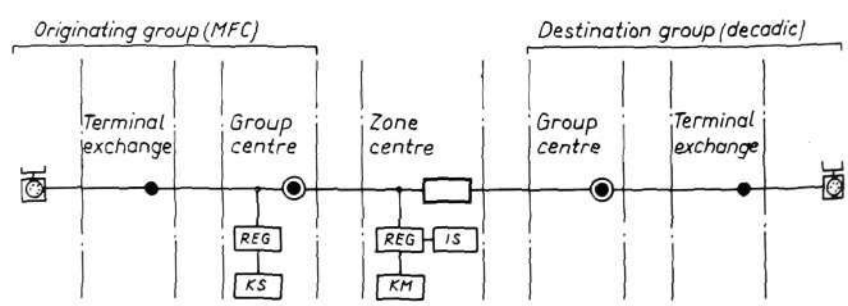


Fig. 3 X 8312

Connection to group with decadic system

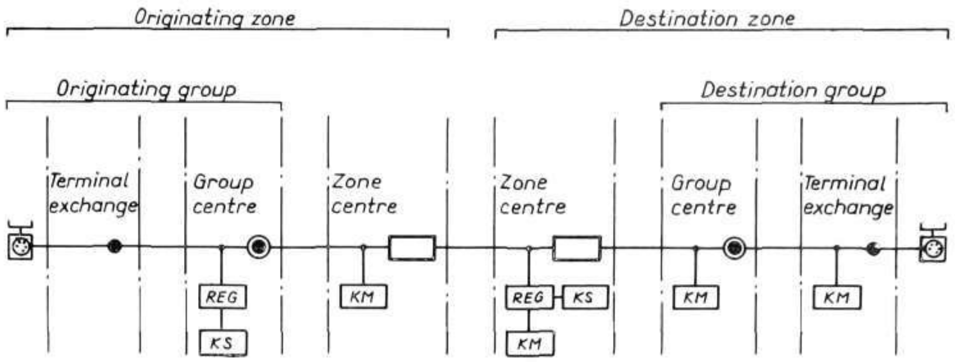


Fig. 4
Connection to other zone

X 8313

zone centre instead. The code receiver *KM* of this register thus receives the necessary digital information from the register at the originating group centre by MFC, and controls the connection to the called exchange by MFC (fig. 4).

Signalling and Switching Processes

First let us consider the general principles of signalling and switching applicable to all types of *ARK 50* exchanges. The processes peculiar to each individual type will be dealt with in a later article.

Initiation of call and transmission of subscriber category

When a subscriber on a terminal exchange *EC* lifts his handset, an idle junction *FUR* is seized to the group centre *KC* (fig. 5). A code receiver *KM* is connected to *FUR* in the terminal exchange, and in the group centre a register *REG* and a code sender *KS* are connected to the incoming junction *FIR*. One of the six available controlling signals is used for transfer to the subscriber category from *KM* to *KS*. The category information is stored in *REG* whereafter *KM* and *KS* are released and dial tone is returned from *REG* to the calling subscriber.

If the terminal exchange is equipped with local registers *REG-L*, one of these is seized if all *FUR* are busy when the subscriber calls.

The subscriber dials the number

The pulses from the subscriber's dial are received and stored by *REG*. From the digital information *REG* must investigate whether

a the length of the number is known and whether the called subscriber may belong to the originating exchange or can be reached via a direct route from that exchange,

b the length of the number is known and whether, by simple means, it can be established that the called subscriber does not belong to the originating exchange and cannot be reached via a direct route from that exchange,

c the length of the number is unknown, which (as a rule) also means that the subscriber belongs to another group area.

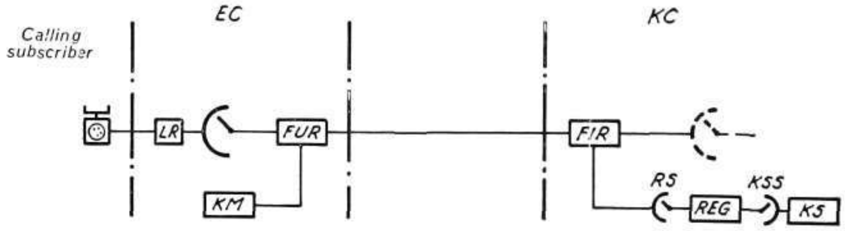


Fig. 5
Local call in terminal exchange

X 8303

To find out to which of these three groups (*a*, *b* or *c*) the number belongs, a simple procedure is required in *REG*. Thus *REG* need not initially know from which exchange the call is originated, but for group *a* numbers the register checks its origin by recalling the originating exchange.

Call-back to originating exchange

If *REG* has established that the number belongs to group *a*, it attempts to connect to the originating exchange after receipt of the last digit. A *KM*-seizure signal is sent to the terminal exchange, where a code receiver is connected to *FUR*. In the group centre a code sender *KS* is connected to *REG* and the stored number is sent to the terminal exchange by MFC and received there by the code receiver.

After each digit the code receiver investigates whether the called party can be reached via the terminal exchange or not, and returns a controlling signal, *A1* or *A5*, respectively. Thus, at this stage, controlling signal *A5* has the special significance that the called party is inaccessible via the terminal exchange.

Local connection

If the called party is on the same exchange as the caller, i.e. the originating exchange, the digital transmission continues with controlling signal *A1* until the code receiver has received the last digit. Information of the called party's line condition is sent to *REG* by means of a B-controlling signal. If the called party is free, connection is established in the terminal exchange; the junction is cleared and code receiver, code sender and register release.

If the subscriber is engaged, code receiver and code sender release and busy tone is returned from *REG* for about 5 seconds, whereafter *REG* and the line are also released. The subscriber is placed on line lock-out and receives busy tone from his line equipment.

If the subscriber's line is intercepted, interception tone can be returned from *REG* or the call can be diverted to an interception equipment or operator.

Connection via direct junction

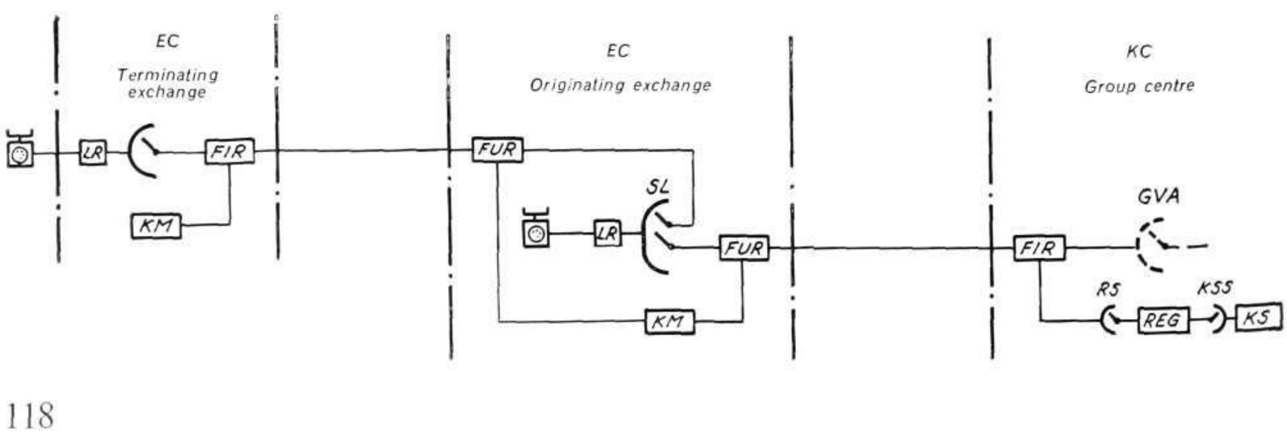
If the code receiver *KM* at the terminal exchange *EC* finds that the connection shall be set up via a direct route, a bypath is established between *KM* and a free junction on the route (fig. 6). If there is no free junction, or if congestion is encountered on the path which is being prepared between the calling subscriber and the direct junction, the code receiver acknowledges with controlling signal *A5*, which indicates that the connection must pass through the group centre.

If there is a free direct junction, the digital transmission continues from *REG* and is received by the code receiver at the called exchange, which was connected on seizure of the junction. The code receiver at the originating exchange is now connected so as not to react to the numerical signals *1–10* (digits *1–0*) but is passed by the MFC signals, which take the bypath out on the direct junction to the destination exchange.

Fig. 6

Call over direct junction

X 7825



After reception of the last digit, information of the called party's line condition is transmitted in the ordinary way and, if the line is free, the connection is set up in the originating and called exchanges. Code receivers, code sender and the junction to the group centre are released. If an engaged or intercepted condition is encountered, the direct junction is cleared and the procedure continues as on a local connection.

Connection via group centre after call-back

If, after reception of a given number of digits, the code receiver *KM* at the originating exchange finds that the called party is not connected to the originating exchange or to an exchange with direct junction from it, *KM* acknowledges with controlling signal *A5*, which indicates that the connection shall be set up through the group centre. The code receiver at the originating exchange then releases.

In the following example we assume that the called party is connected to another terminal exchange in the same group area as the originating exchange (fig. 7). Guided by the digital information stored in *REG*, the selector stages in the group centre are switched to a free line on the route to the destination exchange. A seizure signal is then sent to that exchange and a code receiver there is seized. Since *REG* knows the numbering in its own group area, it can decide which digit to send as first digit to the destination exchange. The digital transmission then starts with this digit and ends with information of the called party's line condition being sent to *REG* in the normal manner.

If the called party is free, connection is established in the destination exchange, and code receiver, register and code sender release. On encountering an engaged or intercepted condition, the connection to the destination exchange is cleared and the subsequent procedure is as already described.

Connection via group centre without call-back

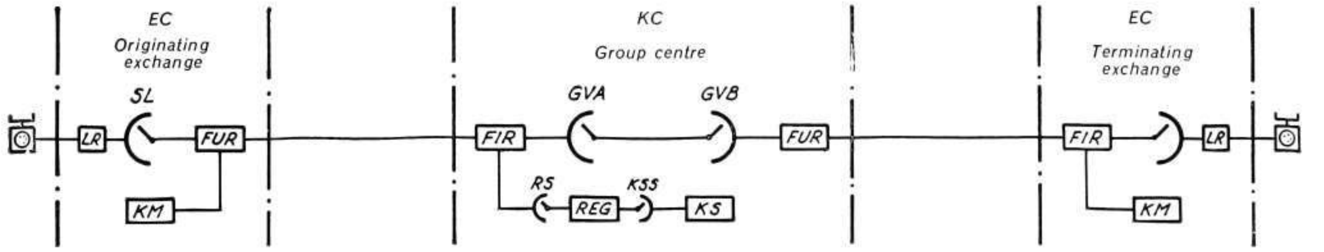
If the received number is of group *b*, in which case *REG* can determine the length of the number and establish that the called party cannot be reached on the originating exchange, it is naturally unnecessary to attempt to connect to it.

Therefore, when *REG* has received the whole number, the group centre selector stages come into operation and the number is transmitted to one or more subsequent exchanges, where the code receiver acknowledges with A-controlling signals. When the code receiver at the called exchange has received the necessary digital information, it sends a B-signal in acknowledgement as indication of the called party's line condition. The subsequent process does not differ in principle from that already described.

If the received number is of group *c*, again no attempt is made to connect to the originating exchange. As the length of the number is unknown to the register, it must begin setting up the connection before the subscriber has dialled the entire number. It is probable, therefore, that the connection will have reached an exchange or a selector stage along the route before the register has received sufficient information from the subscriber to switch the connection through that stage. As the code receivers are common to a large number of circuits (switches) and are designed for short occupation times, one cannot allow a code receiver to be connected before the originating register has itself received the information which it is to send on to the code receiver.

Fig. 7 X 7826

Call to exchange in own group area



In such cases, therefore, it is necessary to switch in a register at the boundary to the area of which the numbering is unknown to the originating register. As a rule use is made of an incoming register in the destination area. This register receives the digital information from the originating register and then controls the connection through to the called party and, from the destination exchange, receives a B-controlling signal (called party's line condition) and returns it to the originating register.

Subscriber Categories

The *ARK 50* system is designed for six subscriber categories, and transmission of these six category indications to the register is done with MFC signals. The registers in the group centres are standardly equipped with facilities for reception and storage of the following four indications of category:

a: Subscriber with complete traffic privileges

b: Subscriber with restricted traffic privileges

c: Coin box line with complete traffic privileges (like *a*)

d: Coin box line with restricted traffic privileges (like *b*)

The registers can, if required, be furnished with supplementary equipment for two additional categories; and by increasing the number of controlling signal frequencies to six, the system can be made for fifteen categories.

The category of the subscriber's line is marked by means of strapping in the marker equipment at the exchange to which the line is connected. The system also incorporates facilities for the subscriber himself to decide whether the line shall be marked as category *b* or *a* by switching a rectifier on or off at his telephone set.

Restricted traffic privileges may imply, for example, that calls out over the home group or zone area shall be barred or that calls at certain rates alone shall be permitted; alternative arrangements can be made by strapping in the group centre route marker.

It is often desirable that an operator should know whether a call comes from a coin box line. Category indications *c* and *d* can be used for this purpose, and in such cases the originating register, after setting up the connection, can send a characteristic tone which is heard by the operator when she answers the call. Such calls can also be directed to separate calling jacks on the manual desks or cause special signals on the calling lamp.

PBX Lines

The *ARK 50* system can be equipped for connection of PBX lines, which can be given any desired numbers within the numbering scheme and need not run in numerical sequence. The lines of any one PBX subscriber, however, must be within the same 1,000s group.

Coin Box Lines

For connection of coin boxes to an *ARK 50* exchange, equipment is usually required on the line for collection of coins etc. Since in some cases the answer signal is needed for indication of collection, the system is designed for transfer of the answer signal from the junction relay set to the coin box line equipment in the form of a pulse on the meter wire. On a no-charge call this answer signal can be suppressed, so that no coin collection takes place.

Direct Junctions

A terminal exchange type *ARK 521*, in addition to the backbone to its group centre, can have direct routes to other terminal exchanges, group centres or zone centres, which may be situated in the same or a different numbering area. For this purpose supplementary units are required in the terminal exchange code receivers, which allow connection of up to three direct routes, each of 12 junctions.

Direct routes can also be provided at group centres, but they are handled in the same way as ordinary alternative-choice routes and require no extra equipment.

Line Lock-out

The switching functions are performed by markers common to several switching units, the markers being released if they do not find a free switching path. The calling subscriber is placed on line lock-out, which means that he receives busy tone from his own line equipment, while all switching equipment is released.

The subscriber is also put on line lock-out if he holds a register for more than 90 seconds. This means that permanent-loop subscriber lines do not block the exchange switches after the time-release of the register.

If the called subscriber is engaged, a busy signal is sent to the originating register, after which the connection is released, so avoiding unnecessary occupation of junctions and switching equipment. Busy tone is sent to the calling subscriber from the register for about 5 seconds, after which he is put on line lock-out unless he has already replaced his handset.

Interception Service

In the *ARK* system the line lock-out condition can be used for interception service. A subscriber who wishes this service simply informs the operator and replaces his handset in the ordinary way. The operator then makes a check call back to the subscriber, who now does not replace and is accordingly placed on line lock-out when the connection is released.

On a call to the intercepted subscriber an interception signal is sent to the originating register, which returns interception tone to the caller until he replaces or the register is time-released.

The register can also be equipped with the facility of setting up a new connection to an interception operator (with transmission of the called subscriber's number, if required) or to an interception unit which may be connected to an answering machine, or of returning a special tone.

Metering

Metering is effected by pulses to the subscriber's meter during the period of the conversation. Use is usually made of the Karlsson principle, under which the first pulse after the subscriber answers comes at random and the subsequent pulses at intervals determined by the rate.

The rate is usually determined at the originating group centre, from which metering signals are sent over the junction to the terminal exchange and are there converted into pulses which go to the subscriber's meter. In principle, however, the determination of fee and transmission of metering signals can be arranged at any exchange along the route, or in the special service equipment if special rates are desired which are not obtainable from the metering equipment at the group centre.

Numbering

The registers at group centres have a normal storage capacity of 8 digits. They also have the facility of cyclic storage, however, which means that, when any of the stored digits has been transmitted from the register, a new digit can be received and stored in its place. Therefore, if the group centre register transmits the received digits to another register along the route, the former register can receive more than 8 digits provided that the storage positions have had time to become free.

Thanks to the cyclic storage arrangement the storage capacity of the group centre registers need not be greater than the number of digits in the areas within which the registers have direct control of connections without the aid of other registers along the route.

In the allotment of numbers to the various exchanges in an area with linked numbering scheme, at least one whole hundreds group must be reserved for each exchange. Thus one hundreds group must not be divided between different exchanges. It is desirable that the registers should have simple means of determining the length of numbers. This is possible if the numbering within a group area is uniform, i.e. if all subscribers have the same number of digits. But, if necessary, the numbers may differ in length within different group areas.

One or more thousands groups should be reserved for each group area, and the thousands groups within a group area should preferably be within the same ten-thousands group.

The purpose of these recommendations is to avoid unnecessary repetitions of a number, but the system does not preclude departures from these principles.

Ericsson LM NEWS *from All Quarters of the World*

Large Order for Telephone Equipment from Tunisia

L M Ericsson has received an order from the Tunisian Telephone Administration for telephone exchange equipment amounting to about 11.5 million kronor. This brings the total orders received from Tunisia up to some 23 million kronor.

The new order involves continued automatization of the national network on the basis of L M Ericsson's modern crossbar switching system in the areas around Tunis, Bizerte, Sousse and Sfax, both for local and long distance connections.

Of the earlier contracted equipment a 1,000-line automatic exchange has already been put into service at Bizerte, and also a 1,600-line P. A. X. serving the government departments in the capital.

By the year end 1962 L M Ericsson expects to have in service about 28,000 lines in Tunisia. It is calculated that the entire installations will be completed during 1964, and Tunisia will then have a highly modern telephone system.

New Deliveries and Order

The first crossbar exchange in Lebanon, an Ericsson ARF exchange, was recently opened at Aley. Its capacity is 2,000 lines.

From Thailand orders have come for four ARF exchanges for Nakorn Sawan, Pitsanuloke, Lampang and Chieng Mai, each of 1,000 lines.

The Helsinki Telephone Co. has ordered an ARF 50 equipment for 3,600 lines and various other telephone material. Automatic transmission measuring equipment for 25 long distance transit exchanges has been ordered by the Finnish PTT.

Iceland has placed orders for thirteen ARK 50 rural exchanges, totalling 1940 lines, six ARM 50 exchanges for 280 long distance circuits, and extension of the 500-switch exchange at Reykjavik/Grensås by 2,000 lines. This is the first stage in the Icelandic PTT's five-year plan for automatization of its telephone network.

Panama has ordered a new 500-switch AGF exchange for Colón to serve 3,000 lines.

During a week's stay in Sweden, the Tunisian Minister of Finance, Ben Salah, took the opportunity of visiting L M Ericsson's plant at Midsommarkransen. He was accompanied by his Chargé d'Affaires in Stockholm, Ridha Klibi, and by the Swedish Ambassador to Tunisia, Lennart Petri. This photograph from their tour of the factory shows the Minister, Ben Salah (second from left), and, behind him, Ambassador Petri and Chargé d'Affaires Ridha Klibi.

Liberian Order for 8 Million Kronor

A contract has been signed between the government of Liberia and Telefonaktiebolaget L M Ericsson for delivery and installation of automatic telephone exchange equipment with cable plant and subscribers' apparatus, totalling about 8 million kronor.

The capital, Monrovia, and eight other towns are to be equipped with telephone exchanges of L M Ericsson's crossbar system. Subscriber-controlled long distance dialling will be used between the exchanges.

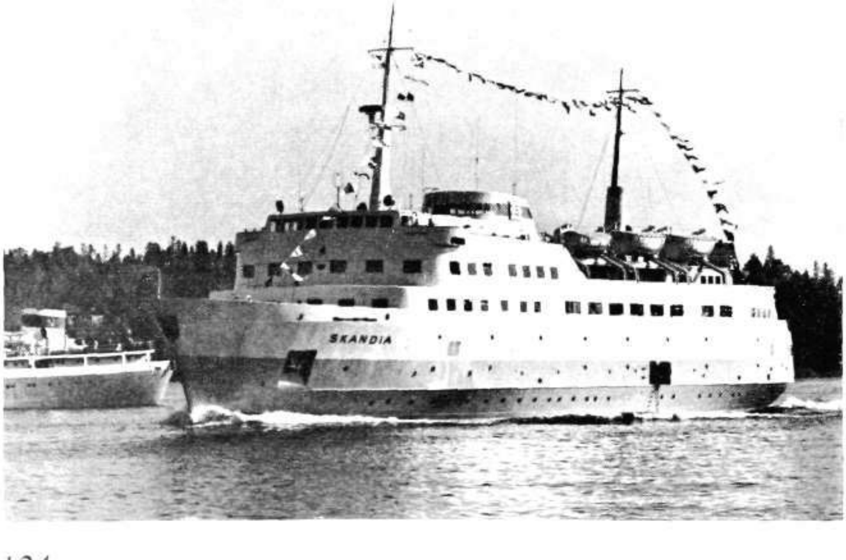
The contract also includes private exchanges of different types for government institutions, hotels, etc.

Certain technical personnel of the Liberian Communications Department will receive training at L M Ericsson's head factory in Stockholm.

(Left) The signing of the contract in Monrovia. (From left) S. Butler, Acting Commissioner of Communications, T. Major, Chief Telephone Engineer, N. P. Speare, Assistant Post Master General, N. Watts, Secretary to the Post Master General, G. Åberg, Chief Engineer of L M Ericsson.

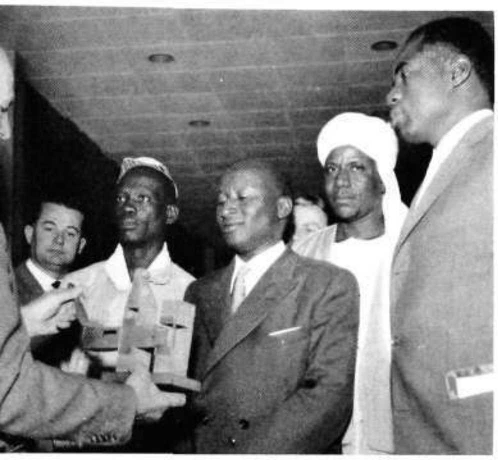
In the building below, which is to accommodate the Ministry of Finance in Monrovia, L M Ericsson is to install a P.A.B.X.

Ericsson Telephones on New Car Ferry



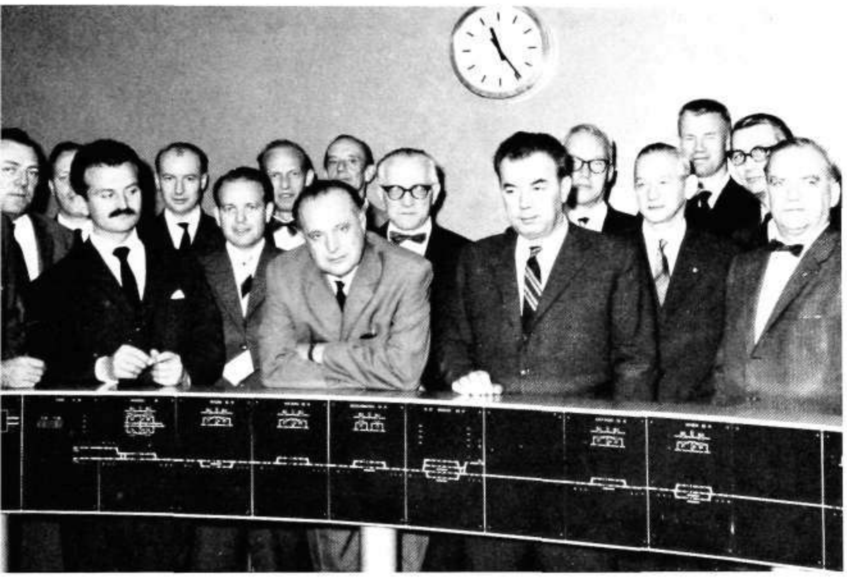
A new ferry with accommodation for 1,100 passengers and 175 motor vehicles has started operating between Norrtälje, Sweden, and Åbo, Finland. Named the »Skandia», it is owned jointly by the shipping companies operating between Stockholm and Helsinki. It is amply equipped with technical devices; the main part of the telecommunications system was supplied by O/Y L M Ericsson A/B of Helsinki.

Apart from telephones for use when the vessel is in port, the installations include intercom systems. There is a sound distribution system, used both for paging and announcements to passengers and crew, and for various forms of entertainment.



The Minister of Industry of the Republic of Niger, M. Adamou Mayaki, (in centre, bareheaded) during a visit to L M Ericsson's head factory.

The U.S. Minister of Labour, Arthur J. Goldberg, on a visit to Sweden at the end of September, was shown round the Midsommarkransen factory. He was accompanied by the U.S. Ambassador to Sweden, J. Graham Parsons (left in photo above). To the right of Mr. Goldberg are seen Hugo Lindberg and Nils Sköldberg of L M Ericsson.



A Yugoslavian delegation, led by the Minister of Communications, M. Cetinić, was recently in Sweden and visited Ericsson plants in Stockholm. (Left) A photograph taken at the C.T.C. Office, Ånge. (From left) P. Kovač, Director of Tesla, Zagreb, M. Iljadica, M. Milović, interpreter, C. Nordström, Swedish Ministry of Communications, S. Thylén and A. K. A. Hurve, Swedish Board of Railways, M. Cetinić, Yugoslavian Minister of Communications, C. Berglund, LME, A. R. Carlstedt, Swedish Railways, R. Jovanović, H. Insulander, L M Ericssons Signal AB, N. Gottberg, Swedish Telecommunications Administration, Capt. L. B. M. Junggren, Swedish Air Force, G. von Sydow, Swedish Ministry of Communications, and F. G. Ekeroth, Swedish Railways.

The official delegation from Nigeria, which was in Sweden at the beginning of October, paid a visit to L M Ericsson in Midsommarkransen. In the photograph (right) is seen, from right, Minister of Trade Z. B. Dipcharina, Minister S. A. Tinubu, and Mr. A. Adekeye.

(Below) Abdul Jabbar Ismail, Director General of Iraqi PTT, on a visit to the head factory.

L M Ericsson Museum at Värmskog

A small timbered cottage in the parish of Värmskog, Värmland, preserves for posterity the story of the poor peasant lad, Lars Magnus Ericsson, who built up a Swedish industry which was to have world-wide ramifications. Birthplace of Lars Magnus Ericsson, the cottage is called Nordtomta, in the village of Vegerbol. Ten years ago it was acquired by the Värmskog Ancient Monuments Association as a memorial of its great son. It was opened as a museum in 1955 and has been a popular tourist resort.

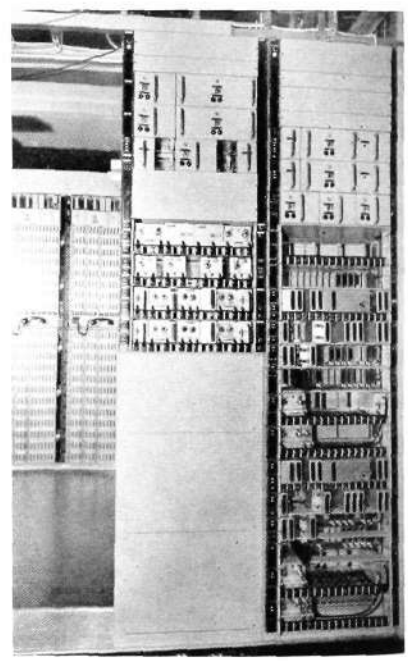
The house has recently been thoroughly restored thanks to grants from Telefonaktiebolaget L M Ericsson, and on August 20, 1961, it was reinaugurated by the Lord Lieutenant of the County, Gustaf Nilsson, who at the same time uncovered the bronze bust commissioned by the company in memory of its founder. The company had earlier donated to the museum a collection of telephone material from its early days, as well as other material associated with the name of Lars Magnus Ericsson.

Terminal Equipments for Coaxial Cables in Sweden

During the summer the Long Distance Division of L M Ericsson completed the lining-up of the first 12 Mc/s carrier terminal equipments for coaxial cables.

The equipments have been handed over to the Swedish Board of Telecommunications and are ready for putting into service on the Stockholm–Västerås–Örebro route. The picture below shows in the foreground some of the bays in the higher modulation stages and, behind them, transistorized channel translating stages forming part of the Stockholm terminal equipment.

Supergroup equipments as well have now been installed at several stations in Sweden.



In the spring and summer The Transatlantic Shipping Co. and The General Export Association of Sweden arranged a floating exhibition on board m/s "Kirribilli" to Australia. The "Kirribilli" visited all large ports en route, including the main commercial centres of the various Australian federal territories. Practically the entire Swedish exporting industry was represented in the exhibition. The L M Ericsson stand on board is seen on the left in the photo below.

A large international exhibition was recently held in the Palazzo dei Congressi in Rome of new equipment for telecommunications and for nuclear instrumentation, especially electronic equipment. In conjunction with the exhibition a series of talks was given on, among other things, the choice of systems for the pending expansion of the Italian long distance network. The Ericsson companies FATME and SIELTE showed a picture display of 12 Mc/s carrier equipments for coaxial cable. In the photo below are seen (right) plug-in units and (left) transistorized bays for carrier equipment from FATME's production.

UDC 621.395.7.003.1
LME 8077

RAPP, Y: *Extension of Telephone Plant with Regard to the Value of Subscribers' Time*. Ericsson Rev. *38*(1961): 4, pp. 92—100.

A paper in Ericsson Technics No. 1, 1961, entitled Extension of Telephone Plant with Regard to the Value of Subscribers' Time, dealt with the question of accessibility and intelligibility on telephone circuits from the aspect of the inconvenience experienced by subscribers, evaluated in monetary terms, as a result of insufficiency in either of these respects. This evaluation is made by estimating the time lost by subscribers owing to congestion of switches and to unsatisfactory transmission on the circuits and by ascribing a value to the time so lost. From this starting point the number of switches on the traffic routes and the diameter of conductors in subscribers' cables can be determined so that the sum of the plant cost and of the economic value of the inconvenience to subscribers is as small as possible. The article explains some of the basic principles involved in the paper in Ericsson Technics.

UDC 621.395.385.4
LME 83134, 8464

BAGER, R & CARLSTRÖM, P: *L M Ericsson's Multi-Frequency Code Signalling (MFC) System*. Ericsson Rev. *38*(1961): 4, pp. 101—105.

The method of transmitting the numerical information in a telephone network has an important bearing on the operating properties of the entire plant. It is therefore important to choose a signalling system which is reliable and rapid, is applicable to all types of circuit, and requires little maintenance. These requirements are met by the signalling system with compelled v.f. code, known as MFC (Multi-Frequency Code) Signalling, which is employed in several Ericsson telephone systems. This article describes the principles and applications of this signalling system, while the equipment itself is dealt with in the following article.

UDC 621.395.385.4
LME 83134, 8464

STORESUND, E: *L M Ericsson's Multi-Frequency Code Signalling (MFC) Equipment*. Ericsson Rev. *38*(1961): 4, pp. 106—112.

This article gives details of the most important transmission requirements for L M Ericsson's MFC signalling system. The method of operation and a description of the v.f. signalling equipment with technical data are also given.

UDC 621.395.344.6
LME 8354

BAGER, R: *Crossbar System ARK 50 for Rural Exchanges*. Ericsson Rev. *38*(1961): 4, pp. 113—122.

L M Ericsson has developed a telephone system ARK 50 for rural exchanges which uses MFC signalling for transmission of the numerical information and for supervision of the setting-up of connections. The system comprises two types of terminal exchange, ARK 511 and ARK 521, and one group centre type, ARK 523. The article deals with the general principles of the system, while the different types will be described in a later article.

The Ericsson Group

Associated and co-operating enterprises

• EUROPE •

Denmark

L M Ericsson A/S *København F*, Finsensvej 78, tel: Fa 6868, tgm: ericsson

Telefon Fabrik Automatic A/S *København K*, Amaliegade 7, tel: C 5188, tgm: automatic

Dansk Signal Industri A/S *København F*, Finsensvej 78, tel: Fa 6767, tgm: signaler

Finland

O/Y L M Ericsson A/B *Helsinki*, Fabianinkatu 6, tel: A8282, tgm: ericssons

France

Société des Téléphones Ericsson *Colombes (Seine)*, Boulevard de la Finlande, tel: CHA 35-00, tgm: ericsson

Paris 17e, 147 Rue de Courcelles, tel: Carnot 95-30, tgm: eric

Great Britain

Swedish Ericsson Company Ltd. *London, W. C. 1*, 329 High Holborn, tel: Holborn 1092, tgm: teleric

Production Control (Ericsson) Ltd. *London, W. C. 1*, 329 High Holborn, *tel: Holborn* 1092, tgm: productrol holb

Italy

Setemer, Soc. per Az. *Roma*, Via G. Paisiello 43, tel: 868.854, 868.855 tgm: setemer

SIELTE, *Soc. per Az. Roma*, C. P. 4024 Appio, tel: 780221, tgm: sielte

F. A. T. M. E. Soc. per Az. *Roma*, C.P. 4025 Appio, *tel*: 780021, *tgm*: fatme

Netherlands

Ericsson Telefoon-Maatschappij, N.V. *Rijen (N. Br.)*, tel: 01692-555, tgm: erictel

den Haag—Scheveningen, 10, Palacestraat, tel: 55 55 00, tgm: erictel-haag

Norway

A/S Elektrisk Bureau *Oslo NV*, P.B. 5055, tel: Centralbord 46 18 20, tgm: elektriken

A/S Industrikontroll *Oslo*, Teatergaten 12, tel: Centralbord335085, tgm: indtroll

A/S Norsk Kabelfabrik *Drammen*, P. B. 205, tel: 1285, tgm: kabel

A/S Norsk Signalindustri *Oslo*, P. B. Mj 2214, tel: Centralbord 56 53 54, tgm: signalindustri

Portugal

Sociedade Ericsson de Portugal, Lda. *Lisboa*, 7, Rua Filipe Folque, tel: 57193, tgm: ericsson

Spain

Cía Española Ericsson, S. A. *Madrid 4*, Conde de Xiquena 13, tel: 31 53 03, tgm: ericsson

Sweden

Telefonaktiebolaget L M Ericsson *Stockholm 32*, tel: 19 00 00, tgm: telefonbolaget

AB Alpha *Sundbyberg*, tel: 282600, tgm: aktiealpha-stockholm

AB Ermex *Solna*, tel: 82 01 00, tgm: elock-stockholm

AB Ermi, *Karlskrona 1*, *tel*: 23010, tgm: ermibolag-karlskrona

AB Rifa Bromma 11, *tel*: 26 26 10, tgm: elrifa-stockholm

AB Svenska Elektronrör *Stockholm* 20, tel: 44 03 05, tgm: electronics

L M Ericssons Driftkontrollaktiebolag *Solna*, tel: 27 27 25, tgm: powers-stockholm

L M Ericssons Signalaktiebolag *Stockholm Sv*, tel: 68 07 00, tgm: signalbolaget

L M Ericssons Svenska Försäljningsaktiebolag *Stockholm 1*, Box 877, tel: 22 31 00, tgm: ellem

Mexikanska Telefonaktiebolaget Ericsson *Stockholm 32*, tel: 190000, tgm: mexikan

Sieverts Kabelverk AB *Sundbyberg*, *tel*: 282860, tgm: sieverts-fabrik-stockholm

Svenska Radioaktiebolaget *Stockholm 12*, Alströmergatan 14, tel: 22 31 40, tgm: svenskradio

AB Östmarks Låsfabrik *Eskilstuna*, Munktellsgatan 5, tel: 31455

Switzerland

Ericsson Telephone Sales Corp. AB, Stockholm, Zweigniederlassung Zürich *Zürich*, Postfach Zürich 32, tel: 325184, tgm: telericsson

West Germany

Ericsson Verkaufsgesellschaft m. b. H. *Düsseldorf 1*, Worringer Strasse 109, *tel*: 84 461, tgm: erictel

Turk[illegible]

Erics[illegible]

Anka[illegible]

dani, [illegible]

ellem

Istanbul, Istanbul Bürosu, Liman Han, Kat 5, No. 75, Bahçekapi, tel: 228102, tgm: ellemist

• ASIA •

India

Ericsson Telephone Sales Corporation AB *New Delhi 1*, P.O.B., 669, reg. mail: 1/3 Asaf Ali Road (Delhi Estate Building), tel: 28512, tgm: inderic

Bombay, Manu Mansion, 16, Old Custom House, tel: 34306 tgm: inderic

Calcutta, P. O. B. 2324, tel: 45-4494, tgm: inderic

Indonesia

Ericsson Telephone Sales Corporation AB *Bandung*, Djalan Dago 151, tel: 8294, tgm: javeric

Djakarta, Djalan Gunung Sahari 26, tel: Gambir 50, tgm: javeric

Lebanon

Telefonaktiebolaget L M Ericsson, *Technical Office Beyrouth*, Rue du Parlement, Immeuble Bisharat, *tel*: 252627, *tgm*: ellem

Thailand

Ericsson Telephone Sales Corporation AB, *Bangkok*, P. O. B. 824, tel: 33991, tgm: ericsson

• AFRICA •

Egypt (UAR)

Telefonaktiebolaget LM Ericsson, *Egypt Branch Cairo*, *P.O.B.* 126, tel: 43684, 50553, tgm: elleme

Rhodesia

LM Ericsson Telephone Co. (Pty.) Ltd. (Branch Office of LM Ericsson Telephone Co. Pty. Ltd. in Johannesburg) *Salisbury, Southern Rhodesia*, P.O.B. 2891, tel: 27001, *tgm*: ericsson

Republic of South Africa

L M Ericsson Telephone Co. Pty. Ltd. *Johannesburg, Transvaal*, P.O.B. 2440, tel: 33-2742, tgm: ericofon

Tunisia

Telefonaktiebolaget LM Ericsson, Technical Office *Tunis*, Boîte Postale 780, tel: 24 05 20, tgm: ericsson

• AMERICA •

Argentine

Cía Sudamericana de Teléfonos L M Ericsson S. A. *Buenos Aires*, Casilla de correo 3550, tel: 332071, tgm: ericsson

Corp. Sudamericana de Teléfonos y Telégrafos S. A. Buenos Aires, Casilla de correo 3550, tel: 332071, tgm: cartefe

Cía Argentina de Teléfonos S. A. *Buenos Aires*, Perú 263, tel: 305011, tgm: catel

Cía Entrerriana de Teléfonos S. A. *Buenos Aires*, Perú 263, tel: 305011, tgm: catel

Industrias Eléctricas de Quilmes S. A. *Quilmes FCNGR*, 12 de Octubre 1090, tel: 203-2775, tgm: *indelqui-buenosaires*

Brazil

Ericsson do Brasil Comércio e Indústria S. A. *Rio de Janeiro*, *C. P. 3601*, *tel*: *43-0990*, *tgm*: ericsson

São Paulo, C. P. 5677, *tel*: 36-6951, tgm: ericsson

Canada

LM Ericsson Ltd. *Montreal 8*, *Que.*, 130 Bates Road, tel: RE 1-6428, tgm: caneric

Toronto 18, *Ont.*, P. O. B. 161 tel: BE 1-1306

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dechile

Colombia

Cía Ericsson Ltda. *Bogotá*, Apartado Aéreo 4052, tel: 41-11-00 tgm: ericsson

Ecuador

Teléfonos Ericsson C. A. *Quito*, Casilla Postal 2138, *tel*: *16100*, tgm: ericsson

Mexico

TeléfonosEricsson S. A. *México D.F.*, Apartado 9958, *tel*: 46-46-40, tgm: coeric

Industria de Telecomunicación S.A. de C.V. *México, D.F.*, Londres No. 47, tel: 250405, *tgm*: industel

Peru

Cía Ericsson S. A. *Lima*, Apartado 2982, *tel*: 34941, tgm: ericsson

Soc. Telefónica del Perú, S. A. *Arequipa*, Casilla de Correo 112, tgm: telefonica

El Salvador

Telefonaktiebolaget LM Ericsson, Technical Office, *San Salvador*, Apartado Postal 188, tel: 4989, *tgm*: ericsson

Uruguay

Cía Ericsson S. A. *Montevideo*, Casilla de Correo 575, tel: 9-26-11, tgm: ericsson

USA

The Ericsson Corporation *New York 17, N. Y.*, 100 Park Avenue, tel: Murray Hill 5-4030, tgm: erictel

North Electric Co. *Galion, Ohio*, P. O. B. 417, tel: Howard 8-2420, tgm: northphone-galionohio

Venezuela

Cía Anónima Ericsson *Caracas*, Apartado 3548, tel: 543121, tgm: ericsson

Teléfonos Ericsson C. A. *Caracas*, Apartado 3548, tel: 543121, tgm: tevela

• AUSTRALIA & OCEANIA •

Australia

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L M Ericsson Trimax Pty. Ltd. *Coburg (Victoria)*, P.O.B. 2

Agencies

• EUROPE •

Belgium

Electricité et Mécanique Suédoises *Bruxelles 5*, 56 Rue de Stassart, tel: 11 14 16, tgm: electrosuede

Greece

»ETEP», S. A. *Commerciale & Technique Athens*, Rue Lycavittou *11*, *tel*: *617041*, *tgm*: *aeter-athinai*

Iceland

Johan Rönning H/F *Reykjavik*, P. O. B. 45, tel: 14320, tgm: rönning

Ireland

Communication Systems Ltd. Dublin, 40, Upper Fitzwilliam Street, tel: 61576/7, tgm: crossbar

Yugoslavia

Merkantile Inozemna Zastupstva *Zagreb*, Pošt pretinač 23, tel: 36941, tgm: merkantile, telex: 02-139

• ASIA •

Burma

Burma Asiatic Co. Ltd. (BAC), Ericsson Department *Rangoon*, P.O.B. 1008, tel: 10999, tgm: ericsson

Ceylon

Vulcan Trading Co. (Private) Ltd. *Colombo 1*, 19, York Street, tel: 36-36, tgm: vultra

China

The Ekman Foreign Agencies Ltd. *Shanghai*, P. O. B. 855, tel: 16242-3, tgm: ekmans

Formosa (Taiwan)

Gadelius & Co. Ltd. *Taipei C*, P. O. B. 682, tel: 29810, tgm: gadeliusco

Hong Kong

The Swedish Trading Co. Ltd. *Hongkong*, P. O. B. 108, tel: 35521-5, tgm: swedetrade

Iran

Irano Swedish Company AB *Teheran*, Khiabane Sevom Esfand 28, tel: 36761, tgm: iranoswede

Iraq

Koopman & Co. (Iraq) W.L.L. *Baghdad*, P. O. B. 22, tel: 6534, tgm: koopiraq

Japan

Gadelius & Co. Ltd. Tokyo C, P.O.B. 1284, tel: 408-2131, tgm: goticus

Kuwait

Latiff Supplies Ltd. *Kuwait*, P.O.B. 67, tgm: latisup

Lebanon

Swedish Levant Trading Co. (Elie B. Hélou) *Beyrouth*, P. O. B. 931, tel: 31624, tgm: skefko

Pakistan

Vulcan Industries Ltd. *Karachi City*, P. O. B. 4776, tel: 32506, tgm: vulcan

Philippines

Koppel (Philippines) Inc. *Manila P. R.*, *P. O. B. 125*, *tel*: *8-93-51*, tgm: koppel

Saudi Arabia

Mohamed Fazil Abdulla Arab *Jeddah*, P. O. B. 39, tel: 2690, tgm: arab

Singapore and Malaya

The Swedish Trading Co. Ltd. *Singapore 1*, 42 Chartered Bank Chambers, Battery Road, tel: 249 64, *tgm*: swedetrade

Syria

Georgiades, Moussa & Cie *Damas*, Rue Ghassan, Harika, tel: 1-02-89, tgm: georgiades

Vietnam

Vo Tuyen Dien-Thoai Viet-Nam, *Saigon*, 34 Dai-lo Thong-Nhut, tel: 20805, tgm: telerad

• AFRICA •

British East Africa

Transcandia Ltd. *Nairobi, Kenya*, P. O. B. 5933, tel. 3312, tgm: transcanda

Congo (Fed. Rep.)

Société Anonyme Internationale de Télégraphie sans Fil (SAIT) *Bruxelles (Belgique)*, 25, Boulevard du Régent, tel: 125070, tgm: wireless (For maritim radio and carrier)

Egypt (UAR)

The Pharaonic Engineering & Industrial Co. *Cairo*, P.O.B. 126, tel: 4-36-84, tgm: radiation

Ethiopia

Swedish Ethiopian Company *Addis Ababa*, P. O. B. 264, tel: 1447, *tgm*: etiocomp

Ghana

The Standard Electric Company *Accra*, P.O.B. 17, tel: 62785, tgm: standard

Liberia

Swedish Agencies Liberia Co. *Monrovia*, P.O.B. 506, tel: 745, tgm: salco

Libya

The Gulf Trading Co. *Tripoli*, P. O. B. 417, tel: 5715, tgm: gultraco

Mauritius

Mauritius Trading Co. Ltd. *Port Louis*, P.O.B. 201, tgm: agentou

Morocco

Elcor S. A. *Tangier*, Francisco Vitoria, 4, tel: 2220, tgm: elcor

Mozambique

J. Martins Marques *Lourenço Marques*, P. O. B. 456, tel: 5953, tgm: tinsmarques

Nigeria

I.P.T.C. Industrial Products Co. (West Africa) Ltd. *Lagos*, Private Mail Bag 2037, tel: 26531, tgm: consult

Sudan

TECOMA Technical Consulting and Machinery Co. Ltd. *Khartoum*, P.O.B. 866, tel: 2224, ext. 35, tgm: sutecoma

• AMERICA •

Bolivia

Johansson & Cía, S. A. *La Paz*, Casilla 678, tel: 2700, tgm: johansson

Costa Rica

Tropical Commission Co. Ltd. *San José*, Apartado 661, tel: 3432, tgm: troco

Cuba

Mc Avoy y Cía *Habana*, Apartado 2379, tel: 7-2527, tgm: macavoy

Curaçao N. W. I.

S. E. L. Maduro & Sons, Inc. *Curaçao*, *P. O. B. 172*, *tel*: *1200*, tgm: madurosons-willemstad

Dominican Republic

García & Gautier, C. por A. Ciudad Trujillo, Apartado 771, tel: 3645, tgm: gartier

Guatemala

Nils Pira *Ciudad de Guatemala*, Apartado 36, tel: 62258, tgm: nilspira-guatemala

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Jamaica and Brit. Honduras

Morris E. Parkin *Kingston*, P.O.B. 354, tel: 4077, tgm: morrispark

Panama

Productos Mundiales, S. A. *Panama*, R. P., P. O. B. 4349, tel: 3-0476, 3-7763, *tgm*: *mundi*

Paraguay

S. A. Comercial e Industrial H. Petersen *Asunción*, Casilla 592, tel: 9868, tgm: pargtrade

Puerto Rico

Splendid Inc. *San Juan*, P. O. B. 4568, tel: 3-4095, tgm: splendid

El Salvador

Dada-Dada & Co. *San Salvador*, Apartado 274, tel: 4860, tgm: dada

Surinam

C. Kersten & Co. N. V. *Paramaribo*, P. O. B. 1808, tel: 4444, tgm: kersten

Trinidad, W.I.

Leon J Aché Ltd. *Port-of-Spain*, 100 Frederick Street, tel: 32373, tgm: achegram

USA

Clark Walter Corporation *Newark 2, N.J.*, 744 Broad Street, tel: Mitchell 3-7333, tgm: wirewalter-newarknj. (For intercom)

State Labs. Inc. New York 3, N.Y., 215 Park Avenue South, tel: Oregon 7-8400, tgm: statelabs (For electron tubes)

• AUSTRALIA & OCEANIA •

New Zealand

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